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SIGNIFICANCE OF SALIVARY ANALYSES UPON SMALL GROUPS OF SUBJECTS[1, 2]

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Very few of the reported chemical analyses of saliva are presented in sufficient detail to make possible the comparison of the various constituents or the calculation of normal values. Becks (1) noted this and also suggested that all calculations be based on the rate of flow of saliva. According to him the amount of calcium, for example, should be expressed as mg. per cc. secreted in the saliva per minute. He claims that chemical studies of saliva have no value unless they meet specifications regarding the standardization of collection, especially in respect to rest or activation and subsequent treatment, measurement of the rate of flow, employment of suitable and accurately checked chemical methods, presentation of full details of methods and results, and the testing of conclusions by statistical methods. In looking for relationships in the occurrence or activity of various salivary factors, we have carried out tests which we believe meet all the suggested specifications.

SOURCE OF SALIVA

Samples were obtained from 20 healthy subjects who had no serious dental defects. No attention was given to the number of fillings present. Physical activities of the subjects were similar, 13 being laboratory workers, and 7 (Nos. 5, 9, 10, 11, 12, 13, 15) high school

[1] The work upon which this report is based was made possible by a grant from the Carnegie Corporation of New York.

[2] Presented at a meeting of the American Association for the Advancement of Science, Philadelphia, December 28, 1940. (Received for publication, January 21, 1941).

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students who appeared at a dental clinic for treatment. Stimulated saliva was obtained by chewing paraffin and collection was made in iced 50 cc. centrifuge tubes. Samples were analyzed immediately. Whole saliva was used throughout.

METHODS

1. *Total nitrogen.* As soon as possible after collection the saliva was stirred well and 2 cc. aliquots taken for nitrogen determinations by the Pregl micro-Kjeldahl method (2).

2. *Protein nitrogen.* The proteins were precipitated by adding to the saliva an equal volume of 1.6 per cent uranyl acetate in a 25 x 200 mm. pyrex test tube. The precipitate was centrifuged and washed 3 times in the tube with 0.8 per cent uranyl acetate. It was then digested in the same tube and the nitrogen determination completed by the Pregl method (2).

3. *Non-protein nitrogen.* This was found by difference, subtracting the protein nitrogen from the total amount.

4. *Catalase activity.* 3 cc. of 0.66 M H_2O_2 was added to 1 cc. of saliva and the mixture incubated at 37°C for 1 hour. One cc. of 20 per cent H_2SO_4 was then added and the undecomposed H_2O_2 titrated with 0.1 N $KMnO_4$. A blank determination was made simultaneously and under the same conditions on another cc. of saliva. Here, however, the H_2SO_4 was added to the mixture before incubation to prevent all enzyme activity. The difference between the amounts of $KMnO_4$ needed to oxidize the blank and the sample represent the amount of H_2O_2 decomposed by the catalase.

5. *Ptyalin activity.* 0.5 cc. of saliva was added to 100 cc. of a 2 per cent boiled starch solution containing 0.05 M NaCl. This mixture was allowed to digest 15 minutes at 40°C. 20 cc. aliquots were withdrawn and analyzed for the amount of reducing sugar formed, using the method of Bertrand (3). Values in Table I are cc. of 0.1 N $KMnO_4$ per cc. of saliva instead of mg. of sugar produced. Tables are available for this conversion (6).

6. *Solids.* 3 cc. aliquots of the mixed saliva were pipetted into a weighed crucible, dried at 110°C to a constant weight, and weighed.

7. *Ash.* The ash in a 3 cc. aliquot of saliva was too small to weigh with any accuracy. The writers question the value of White and

Bunting's ash determinations on 2 cc. aliquots (4) of saliva unless they were weighed on a micro-balance.

8. *Acid neutralizing power.* 3 drops of methyl red indicator were added to 2 cc. duplicate aliquots of the whole saliva. The saliva was then titrated with 0.01 N HCl to a distinct pink color.

9. *Base neutralizing power.* 3 drops of phenolphthalein and an excess of $K_2C_2O_4$ were added to 2 cc. duplicate aliquots of whole saliva. These were titrated with 0.01 N NaOH until pink.

10. *Buffering capacity.* The total buffering capacity was calculated as the sum of the acid-neutralizing and base-neutralizing powers divided by 4 (5). This calculation gives the unit change in pH per unit of acid or base (in this case, cc. of 0.01 N HCl and NaOH) used in the titration. The 4 is the approximate difference in pH between the end points of methyl red and phenolphthalein, or the total change in pH brought about by titrating two aliquots to the end points of methyl red and phenolphthalein with 0.01 N acid and base respectively.

11. *Ash neutralizing power.* The ash from 3 cc. duplicate aliquots was titrated with 0.01 N HCl using 3 drops of methyl red for an indicator.

12. *Starch fermenting power.* Serial dilutions of saliva in distilled water, 1:1, 1:2, 1:4, 1:8, and up to 1:2096, were placed in wells cut in meat infusion agar plates containing 0.1 per cent starch. After refrigeration for 24 hours and incubation for 48 hours, the plates were flooded with a mixture of equal parts of Lugol's solution and tincture of iodine. The highest dilution which gave a zone of 2 mm. in which the purple color of the iodine-starch reaction had not occurred was taken as an index of the ability of saliva to ferment starch.

13. *Bacterial counts.* Direct count of the total bacteria were made on 1:10 or 1:100 dilutions in a hemocytometer. Colony counts were made by mixing 1/10 cc. of 1/10,000, 1/100,000 and 1/1,000,000 dilutions with 10 cc. of plain agar in individual Petri dishes. The plates were incubated at 37°C for 48 hours. Counts of the number of starch fermenting bacteria were made by plating the same dilutions as above in agar containing 0.5 per cent starch. After incubation the plates were flooded with a mixture of equal parts of Lugol's solution and tincture of iodine and the number of starch-digesting colonies determined by counting those showing a clear zone in the purple plate.

14. *Cell counts.* The counts of epithelial cells and leucocytes were made with a hemocytometer (Neubauer ruling). Cells were stained by shaking 2 cc. of the saliva with 1 cc. of a 50 per cent dilution in distilled water of stock methylene blue. The epithelial cell count was made according to the procedure and calculation used for making a white blood-cell count. In determining the number of leucocytes per cc. of saliva, the cells in 80 small central squares were counted and proper calculations were made.

15. *Bactericidal power.* The antibacterial activity of the salivas was determined in well plates, both by the width of the zones of inhibition given by the whole saliva, and by the zones from serial dilutions in sterile distilled water, i.e., 1:1, 1:2, 1:4, 1:8, up to 1:1048. Bactericidal activity was then recorded as being the highest dilution which gave a zone of 2 mm.

16. *Organic buffer.* This is the acid neutralizing power minus the ash neutralizing power.

FINDINGS

The results of the tests are presented in Table I where they all[7] are given as rate of flow, i.e., they represent the amount of any constituent secreted per cc. per minute. The amount per 100 cc. of any constitutent can be found by multiplying its value by 100 and the collection time in minutes.

DISCUSSION

This irregularity of the findings emphasizes the inherent difficulties encountered in salivary analyses. However, because the methods employed are "suitable" and "adequate" (1) we feel justified in presenting them together with the conclusions they indicate.

It is apparent that the variability of any one constituent is as great when based on rate of flow as when expressed in mgm. per cent. Column 5 in Table II shows ranges from 8 fold to 252 fold. These values were obtained by dividing the highest rate by the lowest. Comparing them with corresponding values in Column 3 of the same table, it will be seen that they are invariably larger; their average is more than twice as large. Obviously then, averages taken from 20, or perhaps a few

[7] Except bactericidal power.

TABLE I

Salivary analyses on whole, stimulated saliva

Patient		1	2	3	4	5	6	7	8	9	10
Age	Years	29	32	21	26	16	12	33	21	14	15
Hour of collection	A.M.	9:45–11:15	9:58–10:35	9:25–10:25	9:25–10:35	10:17–11:42	11:25–11:50	10:20–12:50	11:15–11:45 1:25– 1:45	11:15–11:45	11:15–11:45
Time in minutes	Minutes	90	37	60	70	85	85	150	50	30	30
Total volume	cc.	47	30	40	30	25	30	28	30	17	17
Volume per minute	cc. per min.	0.52	0.81	0.67	0.43	0.29	0.35	0.18	0.54	0.57	0.57
Epithelial cells	Number per cc./min.	3.29×10^3	5.95	4.34	2.99	4.64	7.13	2.47	2.62	18.5	13.2
Leucocytes	Number per cc./min.	9.90×10^3	19.87	6.40	7.23	2.02	8.77	6.66	5.93	10.2	3.26
Total bacteria	Number per cc./min.	4.0×10^6	—	2.25	3.03	2.61	4.25	2.64	1.86	7.1	10.6
Total colonies	Number per cc./min.	1.0×10^6	—	50.0	57.1	9.75	11.53	13.33	8.67	13.5	466.6
Starch fermenter	Number per cc./min.	6.78×10^3	—	0.55	1.7	—	—	2.0	1.96	2.1	8.0
Total nitrogen	Mg./cc./min.	5.20×10^{-3}	14.9	8.58	10.63	10.15	10.85	4.10	7.63	26.8	41.8
Protein nitrogen	Mg./cc./min.	4.30×10^{-3}	10.5	5.66	4.97	2.80	5.20	—	—	20.16	29.41
Non-protein nitrogen	Mg./cc./min.	0.91×10^{-3}	4.38	2.85	5.64	7.35	5.65	—	—	6.64	12.39
Solids	Mg./cc./min.	57.7×10^{-3}	170.5	90.0	116.0	64.7	97.6	38.6	83.7	253.4	316.6
Catalase activity	cc. 0.1 N $KMnO_4$/cc./min.	1.0×10^{-3}	—	—	—	22.9	113.0	—	—	185.0	512.0
Ptyalin activity	cc. 0.1 N $KMnO_4$/cc./min.	295.0×10^{-3}	525.0	1260.0	70.2	20.9	242.0	60.15	148.0	833.0	471.0
Acid number	cc. 0.01 N HCl/cc./min.	6.39×10^{-3}	23.4	11.1	9.43	12.23	9.23	3.27	13.9	13.5	19.2
Base number	cc. 0.01 NaOH/cc./min.	3.33×10^{-3}	8.52	2.83	2.14	1.23	2.30	1.83	2.09	12.3	12.0
Buffer capacity	cc. HCl + cc. NaOH ÷ 4/cc./min.	2.43×10^{-3}	8.0	3.5	2.89	3.39	2.88	1.28	4.0	6.5	7.8
Ash number	cc. 0.01 N HCl/cc./min.	5.08×10^{-3}	15.95	6.11	6.48	3.07	8.86	0.69	5.89	12.1	21.5
Organic number	Acid number-ash number	1.32×10^{-3}	7.44	4.97	2.95	9.16	0.37	2.58	8.02	1.4	—
Bactericidal	See text	1:32 L, A. S.	1:256 L, A. S.	1:512 L, S.	1:512 L, S.	1:256 L, S.	1:256 L, S.	1:64 L, A.	1:64 L, A.	1:256 L, A. S.	1:8 S.

Patient		11	12	13	14	15	16	17	18	19	20	Average	Range
Age	Years	13	15	16	33	15	29	30	21	20	23	21.7	12–33
Hour of collection	A.M.	—	10:12–11:12	1:00–2:05	1:50–3:10	2:25–2:45	10:30–12:30	10:12–11:30	10:30–11:30	10:23–11:50	11:00–11:30	—	—
Time in minutes	Minutes	20	60	65	80	20	120	80	60	87	30	66.2	20–150
Total volume	cc.	41	28	31	30	35	46	37	23	22	40	—	—
Volume per minute	cc. per min.	2.05	0.47	0.48	0.37	1.75	0.38	0.46	0.38	0.25	1.33	0.64	0.18–2.05
Epithelial cells	Number per cc./min.	7.40	5.33	3.17	1.27	15.3	3.30	6.48	4.87	3.93	11.46	6.36	1.27–18.5
Leucocytes	Number per cc./min.	3.20	2.76	6.22	25.00	28.1	16.6	10.7	33.3	6.78	66.6	12.43	2.02–66.6
Total bacteria	Number per cc./min.	7.5	2.92	0.63	1.16	17.0	2.29	3.84	2.05	3.76	12.1	4.81	0.63–17.0
Total colonies	Number per cc./min.	50.0	0.12	*10,000.0	10.42	41.8	3.33	229.0	9.02	76.0	606.6	—	0.12–606.6
Starch fermenter	Number per cc./min.	2.15	—	0.31	1.64	5.0	1.66	11.22	14.8	4.25	78.0	8.86	0.31–78.0
Total nitrogen	Mg./cc./min.	24.2	9.78	5.56	7.92	32.75	7.44	12.0	10.63	8.25	—	13.6	4.10–41.8
Protein nitrogen	Mg./cc./min.	15.05	7.55	3.53	5.21	17.0	4.38	7.2	6.97	4.74	13.10	9.3	2.80–29.41
Non-protein nitrogen	Mg./cc./min.	9.15	2.23	2.03	2.71	15.75	3.06	4.8	3.66	3.51	—	5.5	0.91–15.7
Solids	Mg./cc./min.	285.0	130.0	56.9	90.0	245.0	60.8	71.2	77.1	51.7	163.3	125.3	38.6–316.6
Catalase activity	cc. 0.1 N $KMnO_4$/cc./min.	180.0	66.0	11.54	92.5	—	85.8	75.0	206.0	39.1	228.0	139.0	11.5–512.0
Ptyalin activity	cc. 0.1 N $KMnO_4$/cc./min.	283.0	429.0	284.3	300.0	93.0	128.0	345.0	467.0	138.0	473.0	347.1	20.9–1260.0
Acid number	cc. 0.01 N HCl/cc./min.	52.25	19.33	10.07	3.25	33.75	6.54	10.68	10.0	5.86	18.66	14.5	3.25–52.25
Base number	cc. 0.01 NaOH/cc./min.	6.5	0.0	3.0	6.25	19.75	3.0	2.0	4.16	2.65	8.3	5.2	0.0–19.75
Buffer capacity	cc. HCl + cc. NaOH ÷ 4/cc./min.	14.69	4.83	3.27	2.38	13.38	2.39	3.17	3.54	2.13	6.74	4.96	1.28–14.69
Ash number	cc. 0.01 N HCl/cc./min.	24.33	8.83	6.05	—	25.15	4.85	7.34	6.33	6.19	11.44	9.75	0.69–25.15
Organic number	Acid number-ash number	27.92	10.50	4.02	—	8.60	1.69	3.34	3.7	—	7.22	—	—
Bactericidal	See text	1:128 A. S.	1:32 A. S.	S.	S.	S.	S.	S.	S.	A. S.	S.	—	—

* Not included in average.

more, salivary analyses are meaningless by *any* method of calculation, and the hope of establishing normals and finding causal relationships amongst constituents is still small unless a great number of analyses are made. The objection may be raised that in this project we made no study of the systemic conditions of the subjects and that the variations found could be due to differences in metabolism caused by endo-

TABLE II

Range of salivary constituents calculated as milligrams per cent and rate of flow

1 ANALYSIS*	2 RANGE OF VALUES CALCULATED IN AMOUNTS PER CC.	3 RATIOS, HIGHEST AMT./CC. / LOWEST AMT./CC.	4 RANGE OF VALUES CALCULATED IN AMOUNTS PER CC. PER MINUTE	5 RATIOS, HIGHEST RATE / LOWEST RATE
Epithelial cells	102–606	5.0	1.27–18.5	14.6
Leucocytes	64–2,000	31.3	2.02–66.6	33.0
Total bacteria°	41–396	9.7	0.63–17.0	27.0
Total colonies	7–640,000	—	0.12–606.6	—
Starch fermenter	20–2,340	117.0	0.31–78.0	52.0
Total nitrogen°	36.1–125.3	3.5	4.10–41.8	10.2
Protein nitrogen°	22.9–88.2	3.9	2.80–29.4	10.4
Non-protein nitrogen	8.2–62.4	7.6	0.91–15.7	17.3
Solids°	0.37–0.95	2.6	38.6–316.6	8.2
Catalase	0.75–15.4	20.5	11.5–512	44.5
Ptyalin	1.8–27.8	15.5	20.9–1260	60.3
Acid neutralizing power°	26–116	4.5	3.25–52.3	16.1
Base neutralizing power°	10.5–50**	4.8	1.83–19.8**	10.8
Buffer capacity°	18.5–29.5	1.6	1.28–14.69	11.5
Ash neutralizing power	10.3–75.3	7.3	0.69–25.15	36.4
Average		16.8		39.7

* Units and conversion factors same as in Table I.

** 0.0 was lowest value, but meaningless for calculations.

° Show significant differences when correlated with rate of flow of saliva.

crine disturbances, etc. Such an objection seems pointless, however, when we remember that variations of ± 10 per cent (or more) frequently occur in certain phases of "normal" metabolism. Futhermore, a complete metabolic study of each subject is decidedly impracticable.

Considering the group as a whole, few, if any, correlations can be made between the rate of secretion of any constituent and the rate of flow. There is some evidence of an increased *rate* of protein secretion

with increased rate of flow (*fig. 1*), but the correlation is doubtful. Graphs of the other constituents plotted against the rate of flow showed even more irregularity. It must be emphasized again that regardless of the manner of calculation, very little can be concluded from such analyses as these unless a great number of cases is studied. This is true also where results are expressed in mgm. per cent. Although this fact has long been known, investigators seldom use more than 25 cases in any one study group.

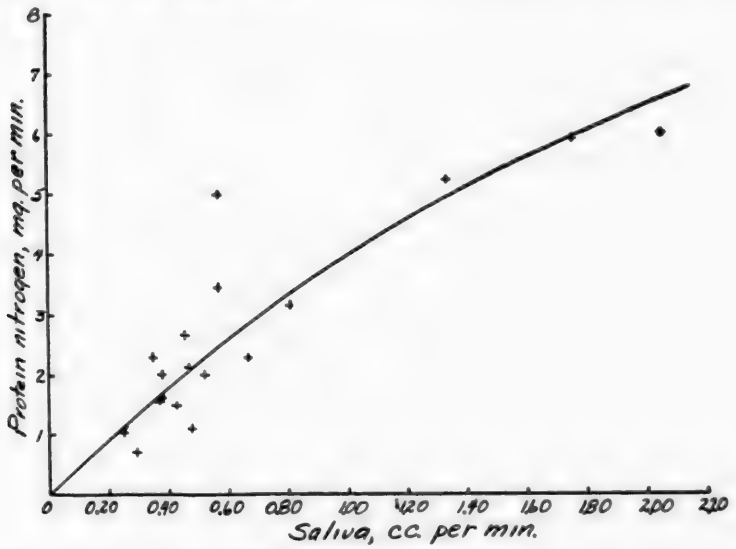

FIG. 1. Saliva, cc. per minute

It is a common practice to compare statistically salivary analyses of 2 small groups and to correlate various salivary "factors" with dental caries. To investigate the possibilities of treating our data in a similar manner, the subjects were divided into 2 smaller groups of 8 each, according to the rate of flow of the saliva. The fastest 8 were put into the "fast" group, the 4 borderline cases were omitted, and the slowest 8 were put into a "slow" group (Table III). The mean value of each constituent in one group was then compared with its mean value in the other group. With all values expressed in amounts per cc. per minute, the statistical significance of the difference of the means in

TABLE III

Significance of differences of constituents in whole saliva when grouped according to rate of flow and age

PATIENT	TOTAL NITROGEN	PROTEIN NITROGEN	NON-PROTEIN NITROGEN	PTYALIN ACTIVITY	ACID NEUTRALIZING POWER	BASE NEUTRALIZING POWER	TOTAL SOLIDS	TOTAL BACTERIA PER CC. PER MINUTE	VOLUME	BUFFER CAPACITY (SEE "METHODS" FOR UNITS)
	mg./cc./min. $\times 10^{-3}$	*mg./cc./min.* $\times 10^{-3}$	*mg./cc./min.* $\times 10^{-3}$	$\times 10^{-3}$	*cc. of 0.01 N HCl per cc. of saliva per minute* $\times 10^{-3}$	*cc. of 0.01 N NaOH per cc. of saliva per minute* $\times 10^{-3}$	*mg./cc./min.* $\times 10^{-3}$	$\times 10^{6}$	*cc./min.*	$\times 10^{-3}$
Rate of flow										
Fast										
1	5.2	4.3	0.9	295.0	6.4	3.3	57.7	4.0	0.52	2.4
2	14.9	10.5	4.4	525.0	23.4	8.5	170.5	—	0.81	8.0
9	26.8	20.2	6.6	833.0	13.5	12.3	253.4	7.1	0.57	6.5
10	41.8	29.4	12.4	471.0	19.2	12.0	316.6	10.6	0.57	7.8
11	24.2	15.1	9.2	283.0	52.3	6.5	285.0	7.5	2.05	14.7
12	9.8	7.6	2.2	429.0	19.3	0.0	130.0	2.9	0.47	4.8
15	32.7	17.0	15.8	93.0	33.7	19.8	245.0	17.0	1.75	13.4
20	—	13.1	—	573.0	18.7	8.3	163.3	12.1	1.33	6.7
Average	28.9	14.6	7.4	437.5	23.3	8.8	202.7	8.7	1.01	8.03
Std. dev. (M_1)	5.6	2.77	2.07	78.0	1.2	2.2	31.3	1.85	0.22	1.46
Slow										
3	8.6	5.7	2.9	1260.0	11.1	2.8	90.0	2.3	0.67	3.5
6	10.8	5.2	5.7	242.0	9.2	2.3	97.6	4.3	0.35	2.9
7	4.1	—	—	60.2	3.3	1.8	38.6	2.6	0.18	1.3
8	7.6	—	—	125.3	11.8	1.8	70.8	1.6	0.54	4.0
14	7.9	5.2	2.7	300.0	3.3	6.3	90.0	1.2	0.37	2.4
16	7.4	4.4	3.1	128.0	6.5	3.0	60.8	2.3	0.38	2.4
18	10.6	6.9	3.7	467.0	10.0	4.2	77.1	2.1	0.38	3.5
19	8.3	4.7	3.5	138.0	5.9	2.7	51.7	3.8	0.25	2.1
Average	8.0	5.4	3.8	208.6	7.7	3.1	72.1	2.5	0.39	2.86
Std. dev. (M_2)	0.77	0.36	0.45	147.0	4.97	0.53	7.3	0.37	0.05	0.31
Difference of averages (D)	20.9	9.2	3.6	228.9	15.6	5.7	130.6	6.2	0.64	5.17
$\sigma_D = \sqrt{M_1^2 + M_2^2}$	5.68	2.8	2.10	167.0	5.11	2.20	32.1	1.88	0.22	1.49
D/σ_D Significance	*3.68*	*3.3*	1.7	1.37	*3.06*	*2.59*	*4.07*	*3.3*	*2.9*	*3.47*
Age										
Significance (D/σ_D) of differences when grouped by age	*2.43*	1.86	—	—	*2.03*	1.4	*2.4*	*2.09*	1.44	*2.02*

the 2 groups was calculated by use of the following formula $M = \sqrt{\frac{\Sigma(d^2)}{n(n-1)}}$ where $\frac{D}{\sqrt{(M)^2 + (M_2)^2}}$ must be greater than 2 for significance. D is the difference of the means of the 2 series of determinations; M is the standard deviation. Similar calculations were also made to compare "old" and "young" groups.

By such calculations, i.e., calculations based on the rate of flow, significant differences between the 2 groups could be shown for all secretory constituents, except non-protein nitrogen and ptyalin activity. However, when the 20 cases were divided into 2 groups of 8 each on the basis of age, averages for total nitrogen, and total solids were still significantly different; averages for acid neutralizing power, total buffer capacity, and even total bacteria in the two groups of 8 were on the verge of significant difference, $\left(\frac{D}{\sigma D} > 2, < 3\right)$. This raises the question of what is really the significant variable. One might just as reasonably conclude that some factors are related to age (or some other factor) as well as to rate of flow.

Furthermore, all components were calculated in mgm. per cent (not amount per minute) and the 20 cases divided into 2 groups according to rate of flow of the saliva and to age, as before. No significant difference between the average amounts of any constituent in the 2 groups (age; rate of flow) was found. Considering both methods of calculation, it is hazardous to suggest what is really significant, if anything.

The preceding calculations convince us of one thing, that is, reports on a limited number of cases, such as continue to appear in the literature, are indeed difficult to interpret, especially when the correlation is made between a highly variable salivary constituent and entities so difficult to measure as erosion and caries activity. Hence, we feel that the only hope of properly correlating salivary factors with anything is a long-time program of routine analyses of large numbers of salivas by adequate methods, preferably by the same group of workers.

SUMMARY

Eighteen different chemical and bacteriological studies were made on 20 samples of stimulated, whole saliva taken from different subjects (Table I) and the results treated by the usual statistical methods.

When the group was considered as a whole, no definite correlation could be found between any constituent studied and the rate of flow, either on an amount-per-cc. basis or on an amount-per-cc.-per-minute basis (*fig. 1*). The range of any constituent was just as great on either basis; in fact, it was greater when the values were expressed on the rate-of-flow basis (Table II).

When divided into "fast" and "slow" groups of 8 cases each, throwing out the 4 cases nearest the mean for the group of 20, there was a significant difference between the rates of flow of total nitrogen, protein nitrogen, acid-neutralizing power, base-neutralizing power, total buffer capacity, total solids, total bacteria, and volume (Table III).

When divided into "old" and "young" age groups, 2 of the 8 significantly different constituents just mentioned were still significantly different and 3 others were on the verge of significance $\left(\frac{D}{\sigma D} > 2, < 3\right)$.

When calculated on an amount-per-cc. basis, no correlation could be found between any constituent and either the rate of flow or age.

The work emphasizes the difficulty of interpreting the results of salivary analyses from small groups, no matter how they are calculated.

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DOES SALIVARY CALCIUM AND PHOSPHORUS COMPOSITION DIFFER SIGNIFICANTLY IN CARIES-FREE AND CARIES-ACTIVE INDIVIDUALS?[1]

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INTRODUCTION

During recent years, many attempts have been made to establish relationships between saliva and dental caries. At the Cleveland meeting of the American Dental Association, reference was made by Fosdick (14) to the effect that

> "Dental caries is probably caused by a complex mechanism governed by a large number of factors that alter the activity of the disease. These variables may be classified into two general groups. One group is of those that tend to cause immunity to the disease. In this group are such variables as acid-neutralizing power of saliva, the degree of saturation with Ca ++ and PO_4 ---, the flow of saliva, the occlusion of the teeth, formation of the teeth, or any factor that would tend to decrease areas in the mouth where stagnation could occur. In immune mouths, the above variables usually furnish a high degree of protection against decalcification of the teeth."

On a previous occasion, Fosdick (12) referred to his experience with salivary analysis of caries-susceptibles and immunes, as follows: "It was found that saliva, unlike blood, has no constant composition. The variation in the composition of the saliva in any one individual was as great as any variations between the two groups, susceptible and immune. For this reason analysis of saliva for any of the easily identified constituents was worthless as a diagnostic measure." In contrast to this, Fosdick (13) supports Karshan's concept, and states that, "If you compare group with group, the immune patients tend to have a higher calcium and higher phosphorus content. You take

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100 susceptibles and 100 immunes, and the immunes will have a higher calcium and phosphorus. . . ." Of course, it is difficult to reconcile these different points of view expressed by the same author.

Krasnow (24) summarized previous findings with respect to salivary calcium content as follows: "Practically every series of observations has yielded higher average values for the caries-free groups than for the caries-susceptible." This author arrived at similar conclusions for the phosphorus content. Karshan (19) summarized the salivary findings of 11 investigators reported between the years of 1929 and 1938. In all but one instance, these showed that the averages for calcium were higher in caries-free than in caries-susceptible individuals. The phosphorus values had a similar tendency.

White and Bunting (34) do not seem to be able to agree with these observations, and state, "Our results do not indicate that the composition of either resting or stimulated saliva is altered by the factor of caries susceptibility."

Generally, therefore, it appears that two approaches have been followed in the past to find a correlation between the product of the salivary glands and dental caries. These are best reflected in the views of Rosebury (28):

> "Karshan's work has shown statistically valid differences in group averages, with respect to certain salivary constituents and characteristics, between persons with active dental caries and those completely free from dental caries. . . . He runs parallel chemical analyses of the saliva of each under identical conditions. He compares the average results and submits the differences to statistical evaluation; and he finds differences between the groups which appear to be significant statistically. Saliva is apparently saturated with respect to calcium and phosphate ions, and within its usual range of pH is incapable of dissolving enamel. It is capable of preventing solution of enamel by acids produced locally in, or introduced into, the mouth. These differences found by Karshan are interesting because their direction is such as to suggest, from theoretical considerations, that the saliva of persons without caries has somewhat greater protective action against solution of enamel by acids than the saliva of individuals with caries. In other words, the saliva from caries-free persons has a somewhat higher content of calcium and phosphate, and a higher carbon dioxide capacity. There are also small average differences in pH and titratable alkalinity between the two groups which fit into the same theoretical pattern."

In brief, the salivary problem today seems to center, for the main part, around (a) factors that might influence the solubility of enamel through the saliva and the closely-related question of saturation of

the saliva with minerals, i.e., the degree of ionization of calcium and phosphorus in saliva, and (b) the levels of calcium and phosphorus in mg. per cent and mg./hr. and the rate of flow.

For the present, the "solubility product principle" is one likely explanation of the mechanism of surface solution of enamel into saliva. The investigations of Karshan and Rosebury (22) of the concentrations of calcium and phosphorus necessary to stop the solution of enamel at different pH values are most interesting, as are the studies of Enright, Friesell, and Trescher (8), Forbes (10), Fosdick and Starke (15), Gore (16), Karshan (18) and Price (26) on the degree of saturation of calcium and phosphorus in saliva. In the saturation studies, all group averages, however, indicate supersaturation in both caries-immunity and caries-activity. The use of these *in vitro* observations and the solubility product principle in explaining the conditions existing in the mouth, however, may become of practical importance only after specific information has been obtained on the ionization of $Ca++$ and PO_4--- in mixed human saliva.

For this reason, we are limited at present to a study of the factors associated with caries immunity and susceptibility, regardless of whether or not they fit into any current theory. A large number of investigations, in particular those of Karshan, have emphasized decided differences between caries-free[2] and caries-active[2] groups, with high values of calcium and phosphorus offering a protection against caries. Some of these have used only a very small number of individuals for comparative purposes, while others have examined large groups which they evaluated biometrically. It has been the experience in this laboratory that the calcium and phosphorus values varied little between patients with high and low caries frequency and a study of previous reports and new experimental evidence was deemed essential for clarification of a suspected difference.

FORMER SALIVARY CALCIUM AND PHOSPHORUS ANALYSES OF RESTING SALIVA OF CARIES-FREE AND CARIES-ACTIVE PATIENTS

Since the earliest calcium and phosphorus analyses of mixed human saliva by Röse (27) in 1905, this problem has been approached by a number of investigators. However, selection of material and pro-

[2] Caries-free and caries-active will hereafter be designated as "CF" and "CA."

cedure varied greatly. In many instances, the caries experience of the individuals examined was not clearly expressed; for instance, Adams and Myers (1) reported comparative studies of individuals with "good, fair and poor teeth," Forbes and Gurley (11) speak of "inactive caries," while Entin (9) refers to "caries resistant" in contrast to a group with "abundance of caries." It is obvious that no definite conclusions can be drawn from a comparison of groups designated by such vague terms. Another factor complicates the picture: some authors investigated the calcium and phosphorus content of only a small number of individuals while others used large groups and evaluated them biometrically. In other instances, the types of salivas used were not always comparable (5, 6, 7); some authors investigated resting, others activated saliva (3, 4). As can be seen from Table 24, p. 331 of Karshan's article (19), the majority examined activated saliva and reported higher calcium and phosphorus values for CF than for CA groups. The impression is left even for this type of saliva that a definite difference between the 2 groups exists. However, a closer examination of these calcium values reveals that only in 2 instances among the stimulated groups (Karshan, Krasnow, and Krejci (21) and Karshan (18)) the difference appears to be large enough to be "statistically significant." The differences between the phosphorus values are even less pronounced, although in all instances the values for CF individuals appear slightly higher. Karshan (19) speaks of his own analyses of stimulated saliva as follows: "Statistical analysis of the data of Karshan showed that the difference between the means of caries-free and active-caries groups bordered on significance, the odds against random occurrence of the difference found being 27 to 1." He furthermore stated, "A similar correlation with caries holds for salivary phosphorus."

It must be pointed out that slight differences of group averages, as, for instance, contained in this table, completely lose their significance since the ranges overlap considerably. Furthermore, even if statistical evaluation should reveal a "significant" difference (33), this can only be interpreted to mean that factors other than chance have led to this difference, not necessarily the presence or absence of caries. On the other hand, it can be noted from Karshan's table that the authors who used stimulated saliva reported calcium and phosphorus results which differ greatly within each group of CF and CA individuals.

Because of the great difficulties which arise in the interpretation of the results of activated saliva (6), the authors felt that primary consideration should be given only to reports of those authors who used resting saliva, collected before breakfast, from healthy individuals who were either completely CF (without cavities or fillings) or CA

TABLE I

Results of former calcium and phosphorus analyses of caries-free and caries-active individuals (resting saliva)

	N		AGE		RATE OF FLOW, CC./HR.				CALCIUM, MG. PER CENT				PHOSPHORUS, MG. PER CENT			
					CF		CA		CF		CA		CF		CA	
	CF*	CA*	CF	CA	Range	M	Range	M	Range	M	Range	M	Range	M	Range	M
Krasnow, 1932	11	14	19–21	19–21						4.9		4.8		16.10 (Inorganic phosphorus)		15.8 Phos-
Krasnow, 1938	12									6.3				15.20		
		Alkaline Saliva 9										6.00				12.6
		Acid Saliva 12										6.40		(Inorganic phosphorus)		15.2 Phos-
White & Bunting	12	13	9–16	9–14	11.4–63.0	28.75	13.8–40.2	24.42	5.00–7.30	5.79	4.94–6.84	5.89	14.1–18.1	16.00 (Total Phosphorus)	14.2–18.4	15.9
Wach	10	14							3.66–10.6	6.9	3.0–8.3	6.30				
Karshan	21	24	11–26	12–30	16.4–42.5	24.36	11.2–45.0	27.11	5.2–9.2	6.5	4.2–7.5	5.70	12.6–28.2	18.5 (Inorganic phosphorus)	11.1–23.7	14.6 Phos-

* CF = Caries-free; CA = Caries-active.

(with a known caries incidence at the time of salivary examination) (Table I). These include Krasnow (23, 25), White and Bunting (34), Wach (29) and Karshan (20).

Krasnow in 1932 and 1938 reported no difference for calcium or phosphorus values in small groups of CF and CA individuals. Al-

though these samples were designated as "unstimulated saliva," it is to be noted that in the 1938 report the specimens were obtained with the aid of a saliva ejector, which hardly makes them comparable to the resting salivas of other authors. Wach as well as White and Bunting, in 1936, also denied finding a relationship between salivary calcium and phosphorus values and dental caries.

One of the latest reports on calcium and phosphorus analyses of CF and CA individuals was made by Karshan (20). Even though this author used unstimulated saliva collected 1 to 3 hours after breakfast, which, in some instances, may not be comparable to resting saliva collected before breakfast, his results are of great interest because they are found to be in contrast with those of Krasnow, White and Bunting, and Wach and do seem to confirm his previous work on stimulated saliva. Karshan reported values for calcium of 6.5 and 5.7 mg. per cent and for phosphorus of 18.5 and 14.6 mg. per cent for CF and CA individuals, respectively. It must be emphasized that on this basis, Karshan is the only author who has found a definite difference, with respect to these 2 minerals, between the salivas of CF and CA individuals.

In view of these contradictory findings, it appeared essential that further investigations of CF and CA groups be made, with attention to several factors (32) which had been held unimportant in the past.

SALIVARY CALCIUM AND PHOSPHORUS ANALYSES OF 90 CARIES-FREE AND 108 CARIES-ACTIVE INDIVIDUALS

A. *Selection of Material and Procedure.* Because of the controversy in this problem, the authors felt that the importance of new original data warranted a detailed tabulation of all observations (Tables II and III).

The validity of statistical evaluation and deductions depends, to a large extent, upon the volume of material examined (33). From Table I, it becomes evident that former investigators of this problem have used only very small groups. This possibly explains the variation of averages as established by the various investigators for the same groups. For any biological fluid such as saliva, which is subject to marked variations (including those due to continual changes in rate of flow, differences in age, etc.), it is essential that large groups be examined, in order to eliminate as far as possible the chance effects of

such factors. For this reason, groups of less than 50 individuals are insufficient.

It must be admitted that it is rather difficult to accumulate a large number of CF individuals; however, the authors finally succeeded in

TABLE II

Chemical analysis of resting saliva of 90 caries-free individuals

ANALYSIS NUMBER	SEX	AGE	RATE OF FLOW CC./HR.	CALCIUM		PHOSPHORUS	
				mg. %	mg./hr.	mg. %	mg./hr.
1077	♀	11	14.5	4.40	0.64	21.0	3.04
1508	♀	12	40.4	4.55	1.84	15.2	6.14
1204	♂	16	30.0	5.30	1.59	22.6	6.78
1739	♂	17	11.2	5.70	0.64	13.0	1.46
1740	♂	17	7.5	6.10	0.46	13.8	1.04
1749	♂	17	12.2	5.50	0.67	11.4	1.39
1750	♀	17	8.7	7.20	0.63	13.9	1.21
1751	♀	17	49.2	6.20	3.05	12.9	6.35
1754	♀	17	20.2	5.75	1.16	11.9	2.40
1759	♀	17	13.2	6.65	0.88	16.4	2.16
1762	♀	17	12.2	4.80	0.58	15.8	1.93
1763	♂	17	14.0	7.40	1.04	20.2	2.83
1765	♂	17	39.3	4.40	1.73	11.4	4.48
1794	♂	17	19.4	5.15	1.00	14.0	2.72
1802	♀	17	21.3	6.05	1.29	13.6	2.90
1348	♂	18	24.0	4.75	1.14	15.1	3.62
1451	♂	18	14.6	4.95	0.72	13.8	2.01
1509	♂	18	17.4	7.15	1.24	15.6	2.71
1738	♂	18	6.2	8.50	0.53	19.1	1.18
1743	♂	18	18.0	5.40	0.97	7.7	1.39
1745	♀	18	8.7	7.35	0.64	14.1	1.23
1747	♀	18	5.7	6.45	0.37	15.9	0.91
1752	♂	18	2.8	8.30	0.23	20.3	0.57
1753	♀	18	18.2	4.75	0.86	16.0	2.91
1756	♂	18	24.7	6.70	1.65	10.4	2.57
1758	♀	18	27.0	3.75	1.01	8.6	2.32
1764	♀	18	14.6	4.80	0.70	8.8	1.28
1791	♂	18	16.0	5.70	0.91	22.2	3.55
1793	♂	18	27.4	6.00	1.64	10.5	2.88
1797	♀	18	17.1	5.55	0.95	18.0	3.08
1799	♂	18	18.0	5.15	0.93	19.6	3.53
1800	♀	18	7.7	7.50	0.58	24.6	1.89
1801	♀	18	40.2	7.35	2.95	12.7	5.09
1736	♂	19	16.8	6.30	1.06	16.7	2.80
1737	♂	19	13.6	5.55	0.75	13.1	1.78
1741	♀	19	14.1	5.70	0.80	12.9	1.82
1742	♂	19	6.0	9.10	0.55	25.2	1.51
1744	♂	19	14.5	7.00	1.02	15.3	2.20
1746	♀	19	11.2	7.15	0.80	20.3	2.27
1748	♂	19	1.6	10.80	0.17	19.2	0.31
1760	♂	19	17.7	4.45	0.79	18.6	3.29
1761	♂	19	17.2	5.60	0.96	16.1	2.77
1766	♂	19	8.7	7.65	0.66	15.7	1.36
1790	♂	19	8.4	8.80	0.74	20.1	1.69
1792	♂	19	17.5	6.20	1.08	12.0	2.10
2324	♀	20	48.0	5.20	2.50	14.5	6.96
6014	♂	20	8.4	7.90	0.66	18.1	1.52
6015	♂	20	19.2	5.65	1.08	13.7	2.63
2026	♀	20	40.0	5.90	2.36	7.7	3.08
6016	♂	20	8.0	7.60	0.61	20.0	1.60
6017	♂	20	22.2	5.10	1.13	11.7	2.60
6023	♀	20	27.8	4.15	1.15	9.1	2.53
6024	♂	20	5.2	11.80	0.61	19.0	0.99
6029	♂	20	11.7	9.25	1.08	11.6	1.36
6037	♂	20	13.9	4.75	0.66	13.8	1.92
6050	♂	20	31.0	4.30	1.33	15.0	4.65
6052	♀	20	3.1	8.00	0.25	21.3	0.66
6053	♂	20	14.5	5.95	0.86	19.6	2.84
6055	♂	20	40.4	4.65	1.88	11.6	4.69
2025	♀	21	85.0	6.20	5.27	6.3	5.36
6012	♂	21	14.6	6.80	0.99	8.7	1.27
6018	♂	21	15.0	7.35	1.10	11.6	1.74
6025	♂	21	18.0	7.05	1.27	16.4	2.95
6026	♀	21	9.2	6.75	0.62	13.3	1.22
6031	♂	21	20.7	7.55	1.56	20.6	4.26
2347	♂	22	3.0	6.30	0.19	22.8	0.68
6022	♂	22	29.0	6.00	1.74	11.9	3.45
6013	♂	23	40.2	7.00	2.81	10.1	4.06
6028	♂	23	13.7	6.00	0.82	11.2	1.53
6056	♂	23	22.4	5.35	1.20	14.8	3.30
6054	♂	23	4.6	7.50	0.34	24.9	1.14
6041	♂	24	32.1	3.90	1.26	11.4	3.67
6049	♂	25	12.7	4.30	0.55	15.1	1.92
2295	♀	26	24.0	7.45	1.79	16.8	4.03
6021	♂	27	39.5	5.25	2.07	16.7	6.60
2139	♀	27	60.0	7.70	4.62	12.0	7.20
2292	♀	30	54.1	6.60	3.57	16.2	8.76
6027	♀	33	10.5	6.85	0.72	14.0	1.47
2301	♀	33	3.7	7.70	0.28	27.1	1.00
2275	♂	33	34.6	5.95	2.06	12.1	4.19
2291	♂	34	21.0	6.95	1.46	11.3	2.37
3152	♂	44	12.0	7.40	0.89	19.9	2.39
3185	♂	48	17.5	7.20	1.26	18.8	3.29
3153	♂	49	24.0	7.45	1.79	17.1	4.10
3225	♂	52	11.1	8.05	0.89	20.4	2.26
3150	♂	53	23.0	11.10	2.55	21.4	4.92
3151	♂	53	21.0	8.25	1.73	18.0	3.78

obtaining the coöperation of 90 persons without decay and 108 with a large number of cavities. Although it would have been more desirable to have an even larger group, it must be noted that the total number examined by the authors exceeds by 4 times the number of Karshan's group and that of White and Bunting.

Caries-Free Individuals: This group of CF individuals was obtained through dental examinations made of students of the University of California.[3] Dental roentgenograms were made to supplement the clinical examination. Among 10,000 students examined, approximately 120 were found to be entirely free from decay and without fillings. Sixty-five of this group submitted to salivary tests for calcium and phosphorus analyses; 45 were males and 20 were females, between the ages of 17 and 27. To this group were added 25 additional CF individuals as young as 11 years and as old as 53, bringing the total to 90 CF individuals.

Since it is not possible to determine caries-immunity solely by clinical examination, the caries activity was measured by the *Bacillus acidophilus* index of Bunting and Jay (17). Sixty-two of the total group of 90 individuals had their saliva checked for *Bacillus acidophilus* on 2 successive days. Of these, 48 (or 77.4 per cent) had zero counts, 11 had combinations of zero and insignificant counts and only 3 had high counts (1,000 to 10,000 colonies). In other words, 95 per cent of these 62 caries-free individuals were negative from the standpoint of the *Bacillus acidophilus* test for caries activity. Unfortunately, it was not possible to obtain these indices for the remaining 28 individuals.[4]

The saliva for analytical purposes was collected under resting conditions (2, 3, 4) and a detailed record was made of the time of collection and volume of sample. The total calcium and inorganic phosphorus determinations were carried out according to the procedures previously reported (30, 31). The mg. per cent and mg./hr. values for calcium and phosphorus are recorded in Table II.

Caries-Active Individuals: For comparison with the 90 CF individuals, a group of 108 CA persons was selected, of which 71 were males and 37 females. Their ages ranged between 10 and 58 years; the majority were between 18 and 25, which constitutes a group of comparable age and environment to the CF. Sixty-six of these

[3] The authors are greatly indebted to Dr. Donald, University Physician, and the dental staff of Cowell Memorial Hospital for their splendid cooperation and assistance in this investigation.

[4] A summary of the general health of all University of California students included in this report, as well as their nutritional histories and food habits, will be included in a separate report.

individuals were again chosen from the student body of the University of California, while the remaining 42 were dental clinic patients. The entire group of 108 individuals had definite caries activity. This was

TABLE III

Chemical analysis of resting saliva of 108 individuals with active caries

ANALYSIS NUMBER	SEX	AGE	RATE OF FLOW CC./HR.	CALCIUM		PHOSPHORUS		ANALYSIS NUMBER	SEX	AGE	RATE OF FLOW CC./HR.	CALCIUM		PHOSPHORUS		ANALYSIS NUMBER	SEX	AGE	RATE OF FLOW CC./HR.	CALCIUM		PHOSPHORUS	
				mg. %	mg./hr.	mg. %	mg./hr.					mg. %	mg./hr.	mg. %	mg./hr.					mg. %	mg./hr.	mg. %	mg./hr.
1195	♂	10	28.0	4.20	1.18	12.6	3.53	1783	♀	18	9.5	6.85	0.65	15.9	1.51	6048	♂	21	6.7	8.10	0.54	12.4	0.83
1286	♂	11	20.0	5.25	1.05	14.2	2.84	1784	♀	18	13.0	6.30	0.82	16.4	2.13	2242	♂	22	32.0	4.95	1.58	12.0	3.84
1290	♀	13	16.6	5.30	0.88	11.1	1.84	1785	♂	18	35.5	4.60	1.63	8.9	3.16	2379	♂	22	10.4	9.00	0.94	12.8	1.33
1296	♀	13	18.6	4.90	0.91	18.6	3.46	1786	♀	18	19.0	5.55	1.05	10.0	1.90	2240	♂	22	16.0	4.95	0.79	12.1	1.94
1400	♂	13	13.6	5.30	0.72	16.7	2.27	1795	♂	18	18.7	7.60	1.42	10.1	1.89	2256	♂	22	8.7	6.30	0.55	22.0	1.91
1300	♂	13	27.1	4.30	1.16	11.0	2.98	1198	♂	19	14.5	5.20	0.75	12.1	1.75	6035	♂	22	18.0	6.85	1.23	13.1	2.36
1222	♂	13	18.7	6.75	1.26	17.8	3.33	1199	♂	19	21.9	5.50	1.20	10.2	2.23	2278	♀	23	8.1	6.60	0.53	28.0	2.27
1366	♀	13	10.0	4.95	0.50	16.2	1.62	1197	♂	19	16.6	5.80	0.96	10.3	1.71	2275	♂	23	22.5	7.05	1.59	12.3	2.77
1225	♂	14	26.0	5.10	1.33	12.1	3.15	1769	♂	19	27.4	5.45	1.49	11.2	3.07	2214	♂	23	32.0	5.65	1.81	23.2	7.42
1229	♂	14	14.6	5.45	0.80	19.6	2.86	1775	♂	19	18.6	6.75	1.26	13.3	2.47	2215	♂	23	45.9	6.75	3.10	9.8	4.50
1280	♀	14	55.0	7.30	4.02	7.3	4.02	1789	♂	19	5.1	5.40	0.28	13.9	0.71	6032	♂	23	7.0	8.30	0.58	20.6	1.44
1328	♀	15	17.5	5.65	0.99	15.4	2.70	2277	♂	20	48.0	6.10	2.93	10.3	4.94	6036	♂	23	8.4	6.00	0.50	17.2	1.44
1182	♂	15	7.7	6.70	0.52	17.5	1.35	2290	♂	20	13.3	5.85	0.78	11.6	1.54	6040	♂	23	4.4	7.20	0.32	13.2	0.58
1221	♀	16	11.2	6.20	0.69	15.4	1.72	2283	♂	20	14.0	5.75	0.80	19.2	2.69	6042	♂	24	11.0	5.50	0.60	17.4	1.91
1211	♀	16	12.0	6.20	0.74	19.8	2.38	2222	♂	20	22.1	4.95	1.09	12.0	2.65	2219	♂	25	19.9	6.45	1.28	20.1	4.00
1219	♀	16	10.4	5.45	0.57	14.5	1.51	2229	♂	20	41.0	5.60	2.30	9.7	3.98	2323	♂	25	18.0	7.50	1.35	14.5	2.61
1247	♀	16	42.5	6.75	2.87	8.3	3.53	6030	♂	20	14.5	5.80	0.84	16.3	2.36	2267	♂	26	11.5	6.05	0.70	15.9	1.83
1772	♀	16	6.8	6.35	0.43	18.1	1.23	6031	♂	20	14.6	7.35	1.07	12.2	1.78	2247	♂	27	10.0	5.95	0.60	19.8	1.98
1196	♀	17	17.8	4.00	0.71	10.6	1.89	6033	♂	20	20.9	4.80	1.00	16.0	3.34	2235	♂	28	54.0	6.50	3.51	13.0	7.02
1276	♂	17	8.4	5.80	0.49	22.0	1.85	6034	♂	20	15.0	6.15	0.92	7.0	1.05	2246	♂	28	40.0	5.30	2.12	15.8	6.32
1770	♀	17	29.2	4.25	1.24	11.8	3.44	6039	♂	20	3.5	5.80	0.20	19.8	0.69	3004	♀	42	5.3	6.45	0.34	21.4	1.13
1774	♂	17	8.1	6.75	0.55	14.5	1.17	6019	♂	20	16.8	6.75	1.13	14.0	2.35	3030	♀	42	28.2	5.85	1.65	20.2	5.70
1776	♂	17	23.3	5.15	1.20	9.1	2.12	6045	♂	20	8.6	6.80	0.58	9.5	0.82	3006	♀	44	16.0	5.15	0.82	16.3	2.61
1787	♂	17	22.7	4.85	1.10	8.9	2.02	6047	♂	20	34.9	5.65	1.97	9.6	3.35	3039	♀	44	6.6	10.00	0.66	31.1	2.05
1788	♂	17	14.8	4.40	0.65	12.3	1.82	2318	♂	21	18.3	6.90	1.26	12.6	2.30	3046	♀	45	9.8	5.30	0.52	29.5	2.89
1796	♂	17	3.2	10.00	0.32	19.9	0.64	2238	♀	21	25.0	7.30	1.82	13.5	3.38	3012	♀	46	8.0	6.25	0.50	22.0	1.76
1798	♂	17	8.3	7.65	0.63	24.0	1.99	2212	♂	21	27.3	6.45	1.76	13.4	3.66	3043	♀	46	26.0	5.80	1.51	13.2	3.43
1262	♂	18	41.3	6.10	2.52	6.3	2.60	2165	♂	21	20.0	7.50	1.50	14.6	2.92	3056	♀	47	3.1	8.75	0.27	31.0	0.96
1768	♂	18	10.6	5.75	0.61	11.9	1.26	2221	♂	21	22.5	5.30	1.19	12.6	2.84	3060	♀	48	6.9	5.30	0.37	9.8	0.68
1771	♀	18	15.8	4.00	0.63	8.8	1.39	2248	♂	21	8.3	8.00	0.66	18.4	1.53	3036	♀	48	9.6	6.75	0.65	24.2	2.32
1773	♀	18	16.4	5.00	0.82	11.1	1.82	2271	♂	21	14.5	5.75	0.83	11.6	1.68	3051	♀	49	11.2	4.95	0.55	23.4	2.62
1777	♀	18	10.0	5.30	0.53	11.0	1.10	2213	♂	21	27.0	4.70	1.27	18.5	5.00	3055	♀	51	21.9	5.60	1.23	15.6	3.42
1778	♂	18	10.2	5.90	0.60	13.1	1.34	6038	♂	21	13.6	5.70	0.78	16.7	2.27	3053	♀	53	3.4	7.50	0.26	29.6	1.01
1779	♂	18	16.1	6.40	1.03	10.1	1.63	6043	♂	21	9.4	7.25	0.68	19.2	1.80	3050	♀	54	9.0	8.30	0.75	34.6	3.11
1780	♂	18	11.4	5.60	0.64	13.1	1.49	6044	♂	21	5.7	5.40	0.31	11.5	0.66	3032	♀	55	5.0	7.30	0.36	38.6	1.93
1782	♂	18	5.6	6.40	0.36	26.8	1.50	6046	♀	21	12.5	4.25	0.53	14.4	1.80	3019	♀	58	18.3	6.35	1.16	24.0	4.39

indicated by the finding of new enamel caries as determined by periodic clinical examinations during the time in which the salivary analyses were made. As in the other group, the caries activity was checked

in 40 instances by the determination of the *Bacillus acidophilus* index on 2 successive days. While only 4 had zero counts and 2 had insignificant findings, the remainder had high counts, most of which were extremely high, rising as far as 300,000 colonies. From the standpoint of the presence of aciduric microorganisms, this group presents a striking contrast to the CF group with a total of 85 per cent against 5 per cent with very high counts. The salivary data were accumulated as in the former group, and are summarized in Table III.

B. *Results.* From the "master charts" (Tables II and III), the ranges, arithmetic means (M), standard deviations (σ) and the statis-

TABLE IV

Statistical evaluation of results listed in tables II and III

	RANGE		M		σ		SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS ($M_{CF}-M_{CA}$)
	CF*	CA*	CF	CA	CF	CA	
Age	11–53	10–58	21.78	23.44	8.35	11.00	No
Rate of Flow, cc./hr.	1.6 –85.0	3.1 –55.0	19.00	17.00	14.40	11.25	No
Calcium, mg. per cent	3.70–11.80	4.00–10.00	6.48	6.06	1.58	1.20	No
Calcium, mg./hr.	0.17– 4.62	0.02– 4.02	1.14	0.99	0.89	0.69	No
Inorganic Phosphorus, mg. per cent	7.7 –25.2	6.3 –38.6	15.33	15.33	4.74	6.03	No
Inorganic Phosphorus, mg./hr.	0.30– 8.76	0.12– 7.42	2.76	2.40	1.70	1.32	No

* CF = Caries-free; CA = Caries-active.

tical significance of differences were calculated and summarized in Table IV.

The ranges for age, rate of flow, calcium and phosphorus mg. per cent and mg./hr. (Table IV) are strikingly similar for the CF and CA groups. Furthermore, the arithmetic means also differs only slightly. As far as the calcium mg. per cent values are concerned, a difference of 0.42 mg. per cent exists in favor of the CF group, while the phosphorus mg. per cent values are identical. The mg./hr. values for calcium and phosphorus vary slightly. The differences between M's of the CF and CA were tested for "statistical significance" (33), which required the calculation of the standard deviation (σ). *In every in-*

stance, the significance of the difference was found to be negative. In other words, the findings of Karshan and his co-workers with regard to statistically significant differences cannot be confirmed in larger

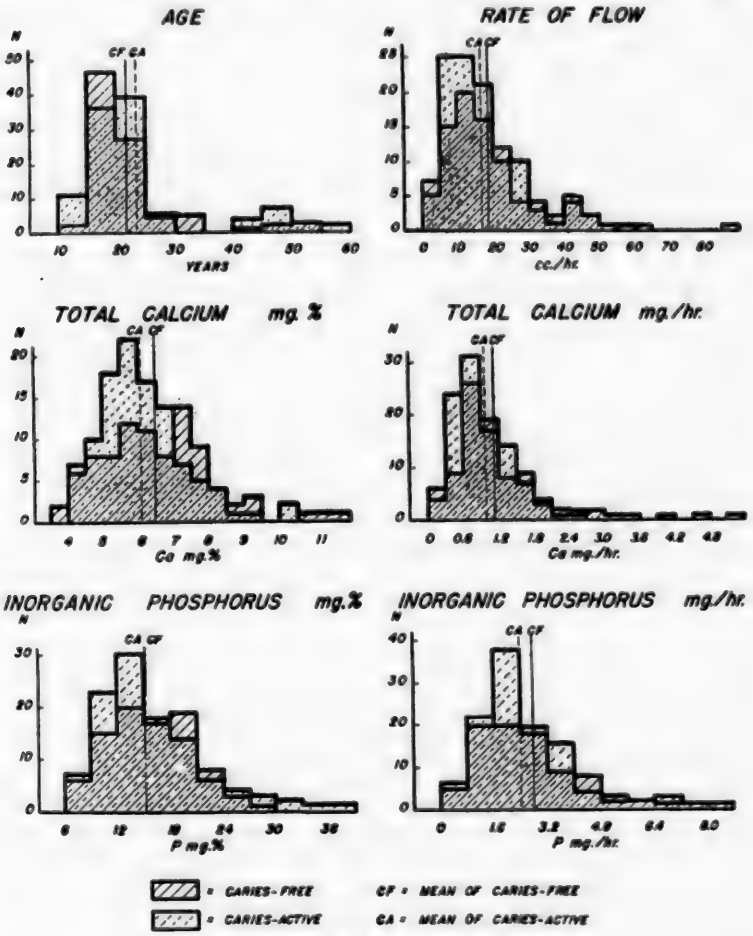

FIG. 1. HISTOGRAMS FOR TABLES II, III AND IV

groups. In fact, as can be noted from Tables II, III and IV, it is possible for a CF individual to have calcium values as low as 3.70 mg. per cent and as high as 11.80 mg. per cent and for phosphorus the

difference can be even greater. All ranges overlap most strikingly and the M's lie closely together, which is clearly demonstrated in the graphical presentation of this material in *fig. 1.*

The fact that the ranges overlap considerably, and, furthermore, the observation that salivary calcium and phosphorus concentration (in mg. per cent) is dependent, to a large extent, upon the rate of secretion and the age of the individual, led the authors to believe that the differences in calcium and phosphorus content which Karshan found to be statistically significant for such small groups as 21 and 24 persons was rather the result of chance variations in the selection of subjects than due to the presence or absence of dental caries.

The influence of rate of flow on salivary composition has been stressed repeatedly and emphasis has been placed on the necessity of always examining the same type of saliva if comparable results are to be obtained. It must be remembered that Karshan examined "saliva collected . . . 1 to 3 hours after breakfast," which unquestionably does not represent typical resting saliva as used in the above investigation. This also may explain the fact that Karshan and also White and Bunting did not report any rates of flow below 11 cc./hr.,[5] whereas it has been customary, in our experience, to find between one-third and one-fourth of all individuals below this figure. This is rather surprising and seems to indicate that the salivas which Karshan used for analysis were either partly stimulated or that individuals with extremely low rates of flow were not considered, possibly because of the difficulty in obtaining a sufficient sample for analysis. In the present examination, these were purposely not omitted, even if the individual was required to spend a long period of time in order to collect an adequate sample. It has been shown (6) that a low rate of secretion is accompanied by a more concentrated saliva with higher mg. per cent values than a high rate of secretion. The arithmetic means of a small group of individuals may readily be influenced by the number of individuals with slow or fast rates of flow, which would be different with every investigation of a small group. The fact that Karshan found a lower calcium mg. per cent value for his CA cases than for the CF may easily be interpreted as being the result of the higher average rate of flow in this group.

[5] By personal communication.

In order to demonstrate the influence of rate of secretion on the means of calcium and phosphorus values, the individuals recorded in Tables II and III with extreme rates were grouped according to high (30 cc./hr. and over) and low rates of flow (below 11 cc./hr.). The low rate of flow group included 24 CF and 37 CA individuals; the high group, 16 and 12, respectively (Table V).

TABLE V

*Influence of rate of secretion on analytical results**

	RATE OF FLOW GROUP	RANGE		M		σ		SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS OF CARIES-FREE AND CARIES-ACTIVE GROUPS	SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS OF HIGH AND LOW RATE OF FLOW GROUPS	
		CF	CA	CF	CA	CF	CA		CF	CA
Rate of Flow, cc./hr.	High	30.00–85.00	32.00–55.00	44.00	41.84	13.19	7.43	No	Yes	Yes
	Low	1.56–10.5	3.10–10.60	6.58	7.56	2.62	2.24	No		
Age	High	12–33	14–28	21.56	20.83	5.34	4.10	No	No	No
	Low	11–53	10–58	20.38	27.19	4.05	13.23	Yes		
Calcium, mg. per cent	High	3.90– 7.35	4.60– 7.35	5.65	5.94	1.11	0.76	No	Yes	Yes
	Low	6.10–11.80	4.95–10.00	7.87	6.81	1.32	1.28	Yes		
Calcium, mg./hr.	High	1.25– 5.27	1.58– 4.02	2.56	2.53	1.10	0.74	No	Yes	Yes
	Low	0.30– 2.07	0.55– 4.50	0.50	0.50	0.18	0.15	No		
Inorganic Phosphorus, mg. per cent	High	7.70–22.60	6.30–23.20	13.04	11.18	3.68	4.37	No	Yes	Yes
	Low	13.80–25.20	9.50–38.6	19.16	19.80	4.25	7.26	No		
Inorganic Phosphorus, mg./hr.	High	3.08– 8.76	1.71– 7.42	5.50	4.56	1.48	1.50	No	Yes	Yes
	Low	0.17– 0.73	0.02– 0.94	1.24	1.46	0.47	0.60	No		

* High rate of flow groups (30 cc./hr. and above): 16 caries-free and 12 caries-active individuals, low rate of flow groups (below 11 cc./hr.): 24 caries-free and 37 caries-active individuals.

By separating the individuals with extreme rates of flow (Table V), contrasting averages were obtained: 44.00 and 6.58 cc./hr. for the CF and 41.84 and 7.56 cc./hr. for the CA. These contrasting averages showed a decided influence on the calcium and phosphorus mg. per cent and mg./hr. values and varied inversely with the mg. per cent values and directly with the mg./hr. values. It must be emphasized, furthermore, that the differences are very pronounced and exceed by far the requirements for statistical significance. In other words, extreme rates of flow can influence the calcium and phosphorus aver-

ages even within the same group, which is without dental decay, to such an extent that statistically significant differences (for instance, that between 5.65 and 7.87 mg. per cent) can be obtained. A similar statistical significance can be found between the averages within the CA group. If the CF and CA groups are compared, the calcium and phosphorus averages vary only slightly.

TABLE VI

*Influence of age on analytical results**

	AGE GROUP	RANGE		M		σ		SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS OF CARIES-FREE AND CARIES-ACTIVE GROUPS	SIGNIFICANCE** OF DIFFERENCES BETWEEN MEANS OF HIGH AND LOW AGE GROUPS	
		CF	CA	CF	CA	CF	CA		CF	CA
Age	High	25–52	25–58	*37.80*	*42.32*	10.37	10.48	No	Yes	Yes
	Low	11–17	10–17	*16.20*	*14.96*	1.87	2.70	No		
Rate of Flow, cc./hr.	High	3.7 –60.0	3.0 –54.0	24.63	15.54	15.54	12.29	No	No	No
	Low	7.5 –49.2	3.2 –55.0	20.89	18.22	12.45	11.19	No		
Calcium, mg. per cent	High	4.3 –11.1	4.9 –10.0	*7.21*	6.52	1.46	1.24	No	Yes	No
	Low	4.4 – 7.4	4.0 –10.0	*5.68*	5.74	0.92	1.28	No		
Calcium, mg./hr.	High	0.28– 4.62	0.26– 3.51	1.75	0.96	1.12	0.74	No	No	No
	Low	0.46– 3.05	0.02– 4.02	1.15	1.02	0.66	0.76	No		
Inorganic Phosphorus, mg. per cent	High	11.3 –27.1	9.8 –38.6	17.13	*21.98*	4.00	7.53	No	No	Yes
	Low	11.4 –22.6	7.3 –24.0	15.14	*14.79*	3.39	4.39	No		
Inorganic Phosphorus, mg./hr.	High	1.00– 8.76	0.68– 7.02	3.89	2.90	2.14	1.67	No	No	No
	Low	1.04– 6.78	0.63– 4.37	3.12	2.34	1.86	0.86	No		

* High age groups (25 years and over): 15 caries-free and 22 caries-active individuals. Low age groups (below 18 years): 15 caries-free and 27 caries-active individuals.

** Statistically significant differences are indicated by italics.

Since former investigators had analyzed the saliva of individuals from varying age groups, it was decided to test the influence of age on calcium and phosphorus values. The individuals of the master charts (Tables II and III) who were over 25 years of age and below 18 were grouped separately (Table VI). The ranges, arithmetic means, standard deviations and statistical significances between CF and CA groups, as well as between high and low age groups within each classification, were again calculated.

It can be noted that contrasting age averages were obtained, i.e.,

37.80 and 16.20 for the CF and 42.32 and 14.96 for the CA. This difference in age is reflected in practically all the calcium and phosphorus values inasmuch as the higher ages are accompanied by higher calcium and phosphorus values. Even though the number of individuals is comparatively small, the differences between high and low age groups is very striking and becomes statistically significant for the calcium mg. per cent values in the CF group and for the phosphorus mg. per cent values in the CA group. This regrouping according to extremes of age did not show any statistically significant difference between CF and CA groups. It did, however, indicate *that within the CF and CA classifications contrasting calcium and phosphorus values were found which even became statistically significant without relation to the caries process whatsoever.*

This demonstration of the effects of the extremes of rate of flow and age on the results shows that their consideration is indispensable in any evaluation of salivary data. According to these observations, any accidental irregular distribution of individuals with either high or low rates of flow or ages may influence the arithmetic means of calcium and phosphorus values to the extent that statistically significant differences will be obtained. This is more likely to occur in small than in large groups and the differences cannot be interpreted as being the effect or cause of dental caries. In large groups such influences may hardly be apparent. Therefore, any slight deviation of arithmetic means which may be encountered in large groups, as, for instance, those of Table IV, should disappear if this is due to an irregular distribution of extremes and if this difference is not due to dental caries. For this reason, the varying numbers of cases with high and low rates of flow and high and low ages were removed from the master groups (Tables II and III). The resultant 50 CF and 50 CA individuals were grouped opposite each other in Table VII. Their ages were between 15 and 24 years and their rates of flow between 11 and 50 cc./hr. The choice of this age range was determined by the fact that it was possible to obtain a sufficiently large number of CF individuals from the student body. Also, previous observations had indicated that a distinct difference existed between the rates of flow and salivary calcium and phosphorus values during the period of active growth from 10 to 14 years of age and those of older ages. The

range for rate of flow was chosen on the basis of the previous reports by White and Bunting (34) and Karshan (20). The recalculation on this basis offered a surprising picture, which is demonstrated in Table VII.

It becomes immediately apparent from an examination of Table VII that not only the slight differences in the averages for age and rate of flow as seen in Table IV have disappeared, but also those of the calcium and phosphorus values. In fact, the averages for CF and CA groups are practically identical and *any suspicion of a relationship between salivary calcium and phosphorus values and dental decay must be abandoned.*

TABLE VII

Salivary analysis of comparable groups of 50 caries-free and 50 caries-active individuals selected according to age and rate of flow*

	RANGE		M		σ		SIGNIFICANCE
	CF	CA	CF	CA	CF	CA	
Age	15–24	15–24	19.54	19.96	1.84	4.46	No
Rate of Flow, cc./hr.	11.2 –49.2	11.0 –48.0	21.50	21.40	10.12	9.85	No
Calcium, mg. per cent	3.75– 9.25	4.00– 7.60	5.74	5.73	1.12	0.92	No
Calcium, mg./hr.	0.58– 3.05	0.53– 3.10	1.20	1.23	0.59	0.61	No
Inorganic Phosphorus, mg. per cent	7.7 –22.60	6.3 –23.2	13.24	12.28	3.93	3.42	No
Inorganic Phosphorus, mg./hr.	1.27– 4.69	1.05– 7.42	2.96	2.64	1.36	1.15	No

* Taken from Master Tables II and III.

The reported differences in salivary calcium and phosphorus composition between CF and CA groups, at least for resting saliva, must be attributed to variation in the selection of material. The above observations on larger groups confirm the previous findings of White and Bunting, and Wach, and are in contrast to those of Karshan.

CONCLUSIONS

1. Salivary analyses of 90 completely caries-free individuals between the ages of 11 and 53 years revealed the following averages: rate of flow, 19.00 cc./hr.; calcium, 6.48 mg. per cent (1.14 mg./hr.); phosphorus, 15.33 mg. per cent (2.76 mg./hr.). 2. Salivary analyses of 108 individuals between the ages of 10 and 58, who were known to have active dental caries, revealed averages for rates of flow of 17.00 cc./hr.;

calcium, 6.06 mg. per cent (0.99 mg./hr.); phosphorus, 15.33 mg. per cent (2.40 mg./hr.). 3. No statistically significant differences could be detected between the caries-free and caries-active groups on the basis of rate of flow or calcium and phosphorus analyses. 4. Extremes of age and rate of flow were found to influence decidedly the calcium and phosphorus averages, regardless of the presence or absence of dental caries. 5. When irregularities in the distribution of individuals with extreme ages or rates of flow were eliminated in the caries-free and caries-active individuals of the total groups, even slight differences of calcium and phosphorus averages disappeared. 6. This investigation emphasizes the lack of any relationship between salivary rate of flow and calcium and phosphorus composition of resting saliva (as expressed in mg. per cent concentration and mg./hr. of secretion) and dental caries.

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THE ISOLATION OF AN ACTINOMYCETES-LIKE ORGANISM FROM ROOT CANALS[1]

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The actinomycetes are a group of fungi, usually classified as hypomycetes, probably bearing a relationship to the acid fast and diphtheroid groups of bacteria. The organisms are commonly found in the soil, and certain types may produce lesions in animals and man. In man the type most often isolated from lesions is *Actinomycetes bovis* with primary lesions about the head and neck in approximately half the cases studied. The infection in man is commonly called "lumpy jaw," characterized by a purulent discharge containing "sulfur granules" and the formation of sinuses and granulation tissue. At the periphery of the lobulated granules are radiating clubs, composed of mycelia slightly thicker at the tip, surrounded by sheaths which take the acid rather than basic dyes. The name "ray fungus" has been given to the actinomycetes because of the appearance of the granules, when examined under the microscope. The club forms are usually seen in tissues, although a few workers have reported formation of clubs in artificial media (1, 2). The granules when crushed and stained are seen to be made up of extremely fine, branching gram positive filaments. When first isolated, the organisms grow best under anaerobic or partially anaerobic conditions, but upon further cultivation most strains will grow aerobically on suitable media.

The mode of infection of the disease is not exactly clear. It is more common among farmers and those who handle grains, straw, etc. For this reason it is thought that the organisms are carried on grains and other vegetable matter to the mouth. The infection in cattle and in man is believed to be caused by the same organism.

Wright (3) suggested that *Actinomycetes bovis* was a normal inhabitant of the secretions of the buccal cavity and intestinal tract, both

[1] Read at the 17th General Meeting of International Association for Dental Research, Cleveland, Ohio, March, 18 and 19, 1939 (*J. D. Res.*, 18: 267, 1939). (Received for publication, February 16, 1941.)

of man and animals. He prophesied that it would be found in fragmented filaments with other bacteria and not differentiated from them. He further states that the part played by foreign bodies is not that of a carrier of the organisms, but that they serve to traumatize the tissues so that the organisms already present develop into characteristic granules and produce the lesions which we call actinomycosis.

Lord (4) studied the contents of carious teeth and tonsils of patients having no indications of mycotic infection. Serial sections made of the material from some of the cases showed what the author considered to be typical actinomycetes. Animals inoculated intraperitoneally, developed omental tumors with formation of club-like structures resembling the ray fungus. Smear preparations from dental cavities showed gram staining filaments, slender and wavy, both long and short forms with branching in only rare instances. Lord did not report the isolation of the organism in pure culture.

Davis (5) described small granules with ray-like structures, resembling in some respects granules of actinomycetes that he isolated from tonsillar crypts. He stated that these granules have been repeatedly mistaken for actinomycetes, but in reality they are very different. He found that these granules were made up of filaments along which were arranged fusiform bacilli spirochetes and cocci in a typical test tube brush arrangement. He reported a similarity between these lesions and those described by Lord. However Davis did not see the clubs definitely described by Lord. Davis further stated that experimentally, intraperitoneal injections of tonsillar granules produced lesions with structures simulating true actinomycetes. Henrici (6), stated that the actinomycetes reported as present in tonsils, pyorrhea pockets and apical abscesses are probably the granules reported by Davis. Tunnicliff and Jackson (7) have succeeded in cultivating these forms anaerobically, the cultures showing the typical test tube brush arrangement. They have named the species *Vibriothrix tonsillaris*.

Emmons (8, 9) reported the cultivation of a saprophytic actinomycetes from teeth and tonsils. He classified the organisms as *Actinomyces bovis*. Lord and Trevett (10) reported the isolation of 4 strains of actinomyces from surfaces and contents of carious teeth and stated that they were like *Actinomyces bovis*.

In the dental clinic at the University of Michigan direct smears

of material removed from root canals have occasionally shown short, branching, gram positive filaments which did not grow in cultures. Recently strains of an organism similar to that seen in direct smears have been isolated from root canals of (7) clinic patients with following case histories. All of these patients were negative as regards systemic infection.

Case I. (C. C.) A 14 year old boy from a rural community had had a blow on the face in the incisor region 2 years before he came to the clinic. Five teeth had devitalized pulps with radiographic evidence of periapical tissue destruction. Only one tooth yielded actinomycetes-like organisms.

Case II. (B. G.) A student about 21 years of age gave a history of receiving a blow in the incisor region about 5 years previously. One of the incisors was discolored and showed a slight swelling over the apical region. Radiographs demonstrated an apical area of translucency.

Case III. (S. L.) Patient was also a student, age 19 years, who came to the clinic because of a toothache due to vital exposure of the pulp.

Case IV. (E. G.) Patient was a student about 22 years of age. He had received a blow across the mouth in an automobile accident 7 years previously. The pulp of the tooth studied was also exposed to caries. Another tooth had been treated 5 years after the accident because of loss of vitality. At that time direct smears had shown gram positive branching filaments which did not grow in cultures.

Case V. (A. G.) Patient was an instructor in the German Department in the University. His history was that of recurrent caries under an old amalgam filling. Radiographs showed a large area of tissue destruction.

Case VI. (P. L.) Patient was an employee in the University Shops who came into the clinic because of a pulp exposure. X-rays showed a slight thickening of peridontal membrane at the apex of the tooth.

Case VII. (F. E.) Patient was a man about 53 years of age who gave a history of pulp death due to a large crown approximating the pulp.

In none of these cases was the organism recovered in pure culture. Three of the patients with histories of trauma had received the injury some time ago, 1 of these and the remaining 4 had open carious lesions allowing the entrance of mouth secretions. The apical lesions in no case resembled a mycosis so that the organisms if related to the actinomycetes were present as saphrophytes. Case IV showed the organisms in direct smears 2 years before they were isolated yet in this time no mycotic lesions had appeared.

METHOD OF ISOLATION

The 7 strains all presented very similar cultural characteristics so that they will not be considered separately. Cultures were all isolated from root canals in a beef infusion broth pH 7.4 containing

0.1 per cent agar, 0.2 per cent glucose and 5 per cent ascitic fluid. This media allows the growth of some anaerobic as well as aerobic organisms. All strains were grown at 37.5°C. Growth appeared on the second day as a faint diffuse cloud around the paper point used to inoculate the media. Quite often it was necessary to incubate cultures a day or 2 longer to be certain of growth. When material from the semi-solid media was transferred to a blood agar plate, growth sometimes appeared in 24 hours, but more often 48 hours, as very minute dew-like colonies.

After the first isolation, all the strains grew well on blood agar, glucose beef infusion agar and plain beef infusion agar, beef extract agar containing starch, as well as beef infusion bouillon, pH 7.4. Strains cultured aerobically at 37.5°C. grew well in 2 days' time. Czepak's medium, a synthetic medium used for the cultivation of actinomycetes, did not give consistent results although sucrose, dextrose, and starch were used as the source of carbohydrate and plates were incubated anaerobically as well as aerobically. Those colonies which did develop were so extremely minute as to be barely visible to the naked eye. They were always few in number and transfers made of these colonies to the same medium, and blood agar, failed to grow.

Colonies on all bacteriological media used were discrete and creamy white in color and after 3 or 4 days' incubation usually showed wrinkled surfaces, some colonies appearing as rosettes. The colonies were extremely tenacious and seemed to send root-like projections into the media. Some colonies were "rougher" than others, and when examined under the microscope branching filaments were seen coming out from the edge of the colony. The colonies were similar to a stock strain of *Actinomycetes bovis*. In broth the organisms grew in 3 days as flakes in the bottom of the tube with no clouding of the media. After 3 to 4 days incubation, growth became rather viscid in some strains. Growth at room temperature (23°–24°C.) on blood agar plates occurred in 3 to 4 days which was slower than that at 37.5°C.

Strains when tested on 3 per cent starch beef extract agar grew extremely well but gave no evidence of diastatic action when tested with iodine solution. When grown in pH 5.7 beef infusion broth

1 per cent glucose after 6 days' incubation, no change in pH was noticed, but growth was scant; grown in pH 6.8 beef infusion broth, no glucose added, did not vary the pH. No pigment was produced nor were aerial mycelia seen on any medium. When grown in beef infusion broth containing 10 per cent gelatin, growth occurred with only 3 strains after 8 days' incubation. The 3 strains did not liquefy gelatin.

Smears made of both colonies and broth cultures showed non-acid fast, gram positive, fine, branching filaments. The filaments measured from .5–.75 microns. Tips of filaments were very often enlarged to give a club-like appearance but this is not the typical club seen in granules of actinomycetes from lesions. The filaments were much shorter than those of the stock strain of *Actinomycetes bovis* but the actinomycetes-like organism had been rapidly subcultured, a condition which Henrici (11) states causes the fragmentation of the mycelium, resulting in bacterial-like growth. Small enlargements at the tips of filaments or rods, which Wright (12) describes in his cultures of actinomycetes as "pear or olive-shaped swellings" could be seen in most of the strains. Coccal forms were seen in some of the older cultures.

ANIMAL INOCULATION

Four animals which were inoculated with 4 strains, intraperitoneally, were killed after 18 days and showed no pathologic lesions on autopsy and sectioning.

CONCLUSIONS

The organisms isolated bear a similarity to true actinomycetes and seem to fulfill Wright's prophesy that the organisms would be found in the oral cavity as fragmented filaments. The organisms are similar to those reported by Emmons and Lord, whose observations are here confirmed. (If these organisms are true actinomycetes, they would seem to fill a rôle analogous to the organisms of Vincent's infection which are present in the mouth without necessarily causing infection.)

The organisms were similar to *Actinomycetes bovis*, in that they were isolated with some difficulty, growing under partial anaerobic conditions and only in media containing body fluids. They formed

branched mycelia with structures similar to the true bovis. After primary isolation, they grew more rapidly than most strains of actinomycetes of human origin, and did not hydrolize starch. (Growth on Czepak's media was doubtful which is not true of the *Actinomycetes bovis*.)

The organisms are interesting because they seem to be similar to *Actinomycetes bovis* and yet are not responsible for any lesions.

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A COMPARISON OF DENTAL CARIES ON THE BUCCAL AND PROXIMAL SURFACES OF PREMOLAR TEETH[1]

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Next in statistical importance to the presentation of total dental caries in large groups of human beings comes the detailed description of the caries process as it affects the various surfaces of the teeth. Dental researchers and practitioners have attempted to classify the lesions of dental caries under various headings (1), and have had the impression that the susceptibility of any given tooth surface would vary with age according to a fairly definite pattern, certain surfaces of the teeth being affected earlier in life than others. More specifically, occlusal and proximal caries have been thought of as lesions of early life, and cervical caries as a lesion of advancing age.

The statistical breaking up of total dental caries into the caries found on each tooth surface presents a difficult problem, chiefly because of the large number of missing, broken down or crowned teeth found in the older age groups. Since there is no record of cavities or fillings that were present on these teeth when they were lost, it is not actually possible to compute a true average for the number of lesions acquired by an individual since birth and expressed in lesions per 100 tooth surfaces. If we were to compute a percentage on the basis of the lesions found, as against the total number of possible surfaces, namely 160, disregarding the fact that some of the teeth were lost, it might even happen in some instances that there would be a spurious appearance of a decrease in the caries incidence with age. This would simply arise from the increase in the number of missing teeth, since such teeth, especially in younger persons, will tend to carry a greater than average proportion of lesions at the time they are lost.

[1] Read at a meeting of the New York Section, International Association for Dental Research, January 28, 1941 (*J. D. Res.*, 20: 158, 1941). (Received for publication March 1, 1941.)

The only acceptable way, therefore, of computing a measure of the incidence of caries per 100 tooth surfaces is to base it entirely on the teeth actually present in the mouth, both as regards the number of lesions found and the number of tooth surfaces present at the time of the examination. In so far as any error is introduced in this measure by the inevitable omission of data for the missing teeth, the error will, especially at the younger ages, tend to give an understatement of incidence, because missing teeth lost on account of caries will tend to have above average incidence.

In the following study, Hyatt's figures on 12,753 employees in the Metropolitan Life Insurance Company have again proved their value. The composition of this group has been described elsewhere (2, 3), and suffice it for the present to say that, although by far the greater number of employees were in the younger age groups, significant samples were obtained covering the entire age range from 17 to 60, and a large range of economic and social status. The data also included 108 cases above the age of 60, but these have been omitted from the present computations. The majority of employees had received fairly adequate dental care, and this care had undoubtedly preserved numbers of teeth that would otherwise have been classed as broken-down or missing. This latter fact contributes considerably to the accuracy of the study. In the Metropolitan data, total conditions for each tooth were tabulated for the entire range of 5-year age groups, and each cavity was described according to the surface or combination of surfaces it affected. Perfect, unerupted, missing, and crowned teeth were also tabulated, together with teeth having compound cavities with and without occlusal involvement.

The proximal and buccal surfaces were chosen as of particular interest for detailed study, since fairly accurate results might be expected for several reasons, as follows. In the first place, proximal surfaces are never entered unless actual proximal caries is present; whereas, on the contrary, the occlusal surfaces of any posterior teeth are so frequently entered to give access to a proximal cavity that any attempt to judge occlusal caries by occlusal involvement in a group of well cared-for dental patients is open to serious error. Cervical caries can be fairly accurately evaluated if those particular teeth are selected in which buccal caries is uncommon in other parts of the crown than the cervical area. In this regard the premolar teeth are

best suited for study, since likelihood of buccal caries in any other position than the cervical is almost eliminated. The same could not

TABLE I

Carious Lesions on Specified Surfaces of Premolar Teeth, Observed Among 12,645 Home Office Employees of the Metropolitan Life Insurance Co., Classified by Age*

TOOTH SURFACE	AGE GROUP								
	16–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59
Buccal									
B	331	465	266	185	168	105	100	56	37
BO	26	24	14	4	3	3	2	1	2
DB**	40	84	52	21	18	11	14	7	5
MB**	42	79	39	19	16	17	8	5	3
Total	439	652	371	229	205	136	124	69	47
Proximal									
D	2,326	2,910	826	452	330	232	185	97	74
M	1,293	1,789	490	272	199	150	115	77	37
2MOD***	254	512	272	152	94	50	58	18	14
DO	1,480	2,645	955	632	390	271	193	118	66
MO	874	1,495	502	343	213	133	120	70	38
DB**	40	84	52	21	18	11	14	7	5
MB**	42	79	39	19	16	17	8	5	3
ML	10	21	13	9	3	6	4	2	—
DL	25	33	22	11	14	10	6	7	5
Total	6,344	9,568	3,171	1,911	1,277	880	703	401	242
Missing, etc.									
Missing	1,895	2,895	1,432	1,184	1,272	1,183	1,237	850	633
Crown	304	946	599	499	407	311	245	125	80
Comp. with Occ.	225	359	151	101	63	37	35	24	17
Comp. without Occ.	7	13	11	6	4	—	3	2	1
Total	2,431	4,213	2,193	1,790	1,746	1,531	1,520	1,001	731
No. Patients	4,343	4,427	1,301	757	591	432	385	250	159

* The date of these observations, taken from Hyatt's study, was 1927.

** Lesions involving *both* categories are included *both* under buccal and under proximal.

*** Doubled as 2 affected proximal surfaces are involved.

be said of the lower molar teeth, for example, since in these the buccal pits are frequently the site of cavities or small or large fillings involving the buccal and cervical areas in such a way that it is impossible to

tell where the caries actually began. The Metropolitan figures recognize no division between parts of the buccal surfaces, nor could they have done so with any accuracy.

In arriving at total buccal caries, a combination of the figures for buccal, buccal-occlusal, disto-buccal, and mesio-buccal caries was made use of. The instances in which caries included the buccal and some other surface constituted only 25 per cent of the total buccal caries, and the probability that an actual buccal entry of caries

TABLE II

Computation Schedule for Percentages of Buccal and Proximal Lesions in Premolar Teeth 12645 Home Office Employees of the Metropolitan Life Insurance Company, Classified by Age, 1927

SYMBOL	CONDITION	DERIVATION	AGE GROUP								
			16–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59
c	Number of Cases		4,343	4,427	1,301	757	591	432	385	250	159
tb	Total Possible Premolar Teeth	8c	34,744	35,416	10,408	6,056	4,728	3,456	3,080	2,000	1,272
mb	Premolars Missing, Crowned or Broken-Down		2,431	4,213	2,193	1,790	1,746	1,531	1,520	1,001	731
ab	Premolars Available for Localized Caries	tb–mb	32,313	31,203	8,215	4,266	2,982	1,925	1,560	999	541
Bf	Total Affected Buccal Surfaces		439	652	371	229	205	136	124	69	47
	Percentage Affected Buccal Surfaces	$\frac{100Bf}{ab}$	1.36	2.09	4.52	5.37	6.87	7.06	7.95	6.91	8.69
aP	Proximal Surfaces Available for Caries	2ab	64,626	62,406	16,430	8,532	5,964	3,850	3,120	1,998	1,082
Pf	Total Affected Proximal Surfaces		6,344	9,568	3,171	1,911	1,277	880	703	401	242
	Percentage Affected Proximal Surfaces	$\frac{100Pf}{aP}$	9.82	15.33	19.30	22.40	21.41	22.86	22.53	20.07	22.37
	Percentage Teeth Missing, etc.	$\frac{100mb}{tb}$	7.00	11.90	21.07	29.56	36.93	44.30	49.35	50.05	57.47

existed in almost all of these combined lesions is so great that there would seem almost no danger in including them in the total count of "buccal" caries, and some inaccuracy in leaving them out. In arriving at the total proximal caries, the figures were combined for distal, mesial, mesial-occlusal-distal, disto-occlusal, mesio-occlusal, disto-buccal, mesio-buccal, disto-lingual, and mesio-lingual caries. The same reasons which admit the lesions combining the buccal and some other surface, also admit the inclusion of lesions combining the proximal and some other surface, and there remains the additional

fact that many of the proximo-occlusal lesions represent proximal cavities which have been filled through an occlusal step.

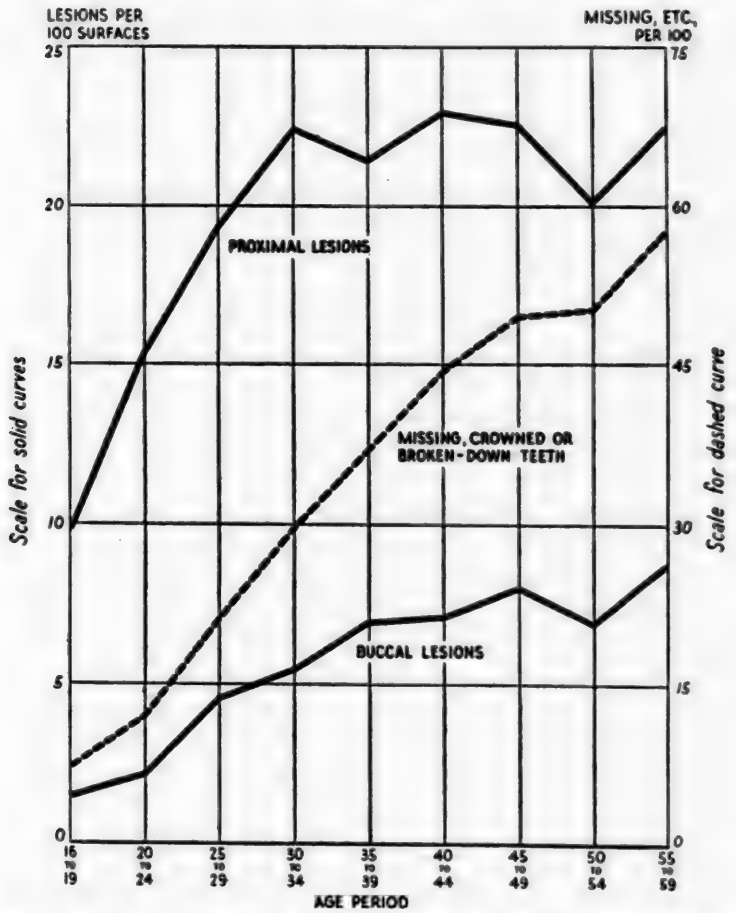

FIG. 1. Buccal and proximal caries in premolar teeth. Experience of 12,645 home office employees, Metropolitan Life Insurance Co.

Fig. 1 shows buccal and proximal lesions found per 100 tooth surfaces, or the proportion (expressed in percent) of buccal or proximal affected surfaces to the number of buccal or proximal premolar sur-

faces *available* for localized caries (i.e., surfaces other than those of teeth which have become missing, crowned or broken-down). These percentages were arrived at by substracting the missing, crowned, or broken down-teeth from the total possible premolar teeth, then, in the case of the proximal surfaces, multiplying by 2, and, finally, dividing the results into the number of affected surfaces. The percentages not only give an accurate picture of the attack of dental caries upon surfaces remaining in the mouth, but, by inference, give a fair and conservative picture of what the total amount of caries would have been had all of the teeth been present in the mouth.

By inspecting the figure and Tables I and II, it will be seen that proximal caries rises rapidly to a high point between the ages of 30 and 34 years, after which the percentage of affected proximal surfaces remains essentially level. Buccal (or, by inference, cervical) caries, on the other hand, continues to rise through the entire period of the study, though less steeply in the latter portion of the curve. It can, therefore, be said that new proximal lesions in this population group occur almost wholly before the age of 30, while cervical lesions show a continued incidence throughout life.

The question of recurrent decay on tooth surfaces already listed as affected by caries cannot be taken up in this study, inasmuch as no differentiation between primary and recurrent lesions was made in the transfer of the original records. Recurrent lesions, of course, would be difficult to assign importance to, since they may almost as easily result from an impairment of hygiene at the margins of imperfect fillings or the actual failure of the fillings themselves as from a renewal of the conditions which caused the initial lesion.

CONCLUSION

Between the ages of 17 and 60 years, 12,645 employees of a large insurance company located in New York City exhibited an incidence of proximal premolar caries occurring almost entirely before the age of 34, and an incidence of buccal, hence by inference cervical, premolar caries occurring steadily throughout the entire period of the study.

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the statistical presentation of the material, and to Dr. Thaddeus P. Hyatt who assembled the original material.

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STUDIES ON DENTAL CARIES[1]

XII. Comparison of the Caries Susceptibility of the Various Morphological Types of Permanent Teeth

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INTRODUCTION

Clinical experience has long made it apparent that the several morphological types of permanent teeth differ in their tendency to be attacked by caries. However, available data (1–6) do not provide a fully quantitative exposition of these differences. On analysis, this situation may be shown to arise out of the fact that comparisons of the susceptibility of the several types of teeth have not, heretofore, taken complete account of differences among the teeth in the length of time they are exposed (after eruption) to the risk of attack by caries. Values for this variable, which has been designated by the term "post-eruptive tooth age" have recently been obtained. These values are used in the present study to identify and compare the orders of susceptibility of the different morphological types of permanent teeth.

METHOD

Basic data for the present analysis were obtained from dental examinations of more than 6,000 boys and girls attending the elementary and high schools of 6 communities located in Washington County, Maryland (Hagerstown and environs). Table I shows, by sex and age at last birthday, the distribution of children examined. Full description of the recording and punch card machine-processing methods developed for the collection and analysis of these data has been given in a previous paper (7).

For the purpose of comparing the caries susceptibility of the different types of permanent teeth 2 types of data were assembled from the clinical examination findings.

The first type of data consists of observations on the number of teeth, per 100 children of a particular age, of each morphological type showing evidence of attack by caries. Such evidence was considered established whenever a tooth showed an open carious lesion or a filling, or had been extracted from the mouth. A tooth affected by any of these stigmata of caries experience is designated by the symbols "DMF" (decayed, missing, or filled) (8).

[1] Received for publication March 7, 1941.

Any tooth so designated is considered *ipso facto* to have displayed susceptibility to caries. Thus, by definition the susceptibility of any tooth is established by the presence of the DMF condition, irrespective of the amount of involvement of surfaces or the extent and severity of the attack.

The second type of material assembled for the present study is made up of quantitative estimates of the accumulated number of years, per 100 children of particular age, that the individual types of teeth have been exposed in the mouth after eruption. These estimates were obtained through a statistical procedure described in detail in earlier reports (9, 10).

Sex Differences in the Caries Experience and the Posteruptive Age of Morphological Types of Permanent Teeth. A previous analysis (11) has shown that, at the same chronological age, girls exceed boys in their total number of DMF teeth of all morphological types. This fact is explained by the parallel observation that, at the same chronological age, girls also exceed boys in their over-all posteruptive tooth age. Sex differences in caries experience which exist for each of the individual types of teeth are explained in like manner by

TABLE I

Number of elementary and high school children of Hagerstown, Maryland and environs who received dental examinations

Data arranged by specified age and sex groups

SEX	CHRONOLOGICAL AGE IN YEARS (LAST BIRTHDAY)														
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	All Ages
Boys	171	197	231	253	270	262	299	272	341	325	193	172	74	27	3087
Girls	156	206	256	240	259	269	297	293	354	326	252	183	74	5	3170
Both sexes	327	403	487	493	529	531	596	565	695	651	445	355	148	32	6257

sex differences in the posteruptive ages of the separate teeth (12). These latter findings justify combining the data for both sexes. Accordingly, the analysis given in the present report is undertaken with material so combined.

ANALYSIS

DMF Teeth. The numbers of DMF teeth observed, per 100 children of both sexes and of the single age groups, are given in Table II. The values shown in the table represent *one-half* the number of *right and left* teeth of each morphological type found DMF per 100 children of specified age. For example, the value, "9.79," which appears near the bottom of the first vertical column on the left of Table II represents one-half the observed number of left and right mandibular first molars showing the DMF condition, per 100 boys and girls 6 years of age at their last birthday. The DMF values given for the other teeth are obtained in like manner. The data are presented in this form since it has been shown repeatedly that the right and left members of pairs

TABLE II

Number of specified teeth affected by caries experience (DMF), per 100 children of specified chronological ages (last birthday)

Data derived from dental examination of 6,257 elementary and high school children of Hagerstown, Maryland and environs.

Both sexes

CORRESPONDING TEETH OF EITHER SIDE (RIGHT OR LEFT)	CHRONOLOGICAL AGE (LAST BIRTHDAY)													
	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Upper jaw														
First Incisors	—	—	0.72	4.77	5.67	8.85	14.18	15.14	18.92	18.90	21.58	22.96	27.37	28.13
Second Incisors	0.16	—	0.41	3.76	4.64	9.04	12.25	14.43	17.56	19.97	22.70	23.66	31.09	34.38
Canines	—	—	—	0.31	0.10	—	0.25	1.42	1.80	2.46	2.48	5.78	8.45	9.38
1st Premolars	—	0.13	0.31	1.32	2.27	3.39	5.12	7.17	10.29	13.29	15.96	19.02	26.02	29.69
2nd Premolars	—	—	—	0.92	1.89	3.11	4.95	7.17	10.79	13.83	16.07	25.22	30.07	28.13
1st Molars	4.13	10.92	21.67	34.49	43.95	44.26	51.60	60.27	64.97	72.81	74.27	71.83	78.05	76.57
2nd Molars	—	—	—	0.10	0.10	1.51	3.78	10.45	21.44	33.03	40.23	44.23	50.00	50.00
Lower jaw														
First Incisors	—	0.13	—	0.82	1.23	0.75	1.43	2.39	2.66	2.54	2.70	3.38	5.41	3.13
Second Incisors	—	—	—	0.61	0.57	0.85	1.43	1.68	1.23	2.31	2.70	3.52	3.38	3.13
Canines	—	—	—	—	0.10	—	0.17	0.18	0.22	0.54	0.34	1.13	2.37	1.56
1st Premolars	—	—	0.11	0.31	0.57	0.85	1.26	1.95	1.52	2.92	3.49	4.65	7.44	9.38
2nd Premolars	0.46	0.13	0.41	0.71	2.55	2.92	3.86	5.31	8.13	12.68	11.69	20.28	20.27	34.38
1st Molars	9.79	25.07	36.25	52.64	61.44	62.90	68.38	75.22	80.94	84.03	84.16	82.68	84.80	89.07
2nd Molars	—	—	—	0.10	0.57	3.77	14.18	24.96	40.65	52.69	60.45	58.03	61.15	65.63

TABLE III

Number of years specified teeth have been in the mouth (post eruptive tooth age), per 100 children at specified chronological ages

Data derived from dental examinations of 6,257 elementary and high school children of Hagerstown, Maryland and environs.

Both sexes

CORRESPONDING TEETH OF EITHER SIDE (RIGHT OR LEFT)	CHRONOLOGICAL AGE													
	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5
Upper jaw														
First Incisors	5.57	39.74	118.86	215.13	315.18	415.68	515.44	616.04	715.77	815.52	917.42	1015.95	1115.50	1205.53
Second Incisors	1.12	10.49	47.00	119.02	212.10	311.80	411.40	512.38	616.94	711.54	814.62	912.23	1011.50	1095.35
Canines	0.01	0.08	0.79	4.95	20.72	59.28	125.38	213.27	309.20	408.06	512.47	608.18	707.00	780.88
1st Premolars	0.14	1.11	6.30	24.89	67.85	138.97	228.34	326.12	425.32	525.03	627.26	725.53	825.00	913.32
2nd Premolars	0.15	0.98	4.61	16.07	43.80	94.25	166.65	255.63	351.83	450.53	553.39	651.08	750.50	837.78
1st Molars	24.55	94.86	191.36	290.79	390.82	491.00	590.91	691.19	791.10	891.01	991.67	1091.16	1191.00	1287.57
2nd Molars	—	0.01	0.07	0.54	3.48	15.87	49.27	113.56	199.28	295.03	396.99	495.47	595.00	684.69
Lower jaw														
First Incisors	43.30	122.91	221.14	319.17	419.28	519.96	619.63	720.75	820.38	920.03	1022.65	1120.62	1220.00	1306.25
Second Incisors	4.56	34.02	107.61	202.54	302.46	403.02	502.75	603.12	702.81	802.53	904.69	1003.01	1102.50	1191.16
Canines	0.01	0.15	2.23	14.59	53.91	126.84	218.90	318.90	418.20	517.56	622.47	718.66	817.50	891.72
1st Premolars	0.06	0.62	4.21	18.30	54.69	119.52	205.03	301.89	400.96	500.54	603.75	701.26	800.50	883.66
2nd Premolars	0.16	0.92	4.11	13.87	37.26	81.16	146.01	230.12	326.38	424.54	526.92	624.68	724.00	808.88
1st Molars	44.53	124.78	223.22	321.79	421.88	522.43	622.16	722.60	822.30	922.03	1024.12	1125.00	1222.00	1311.00
2nd Molars	0.01	0.05	0.43	2.24	9.77	32.49	80.48	155.63	247.79	345.53	446.99	545.47	645.00	734.69

of teeth of the same morphological type tend to have about the same rate of attack by caries. Accordingly, the tabled values are considered to apply to particular teeth of either the right or left side of the mouth.

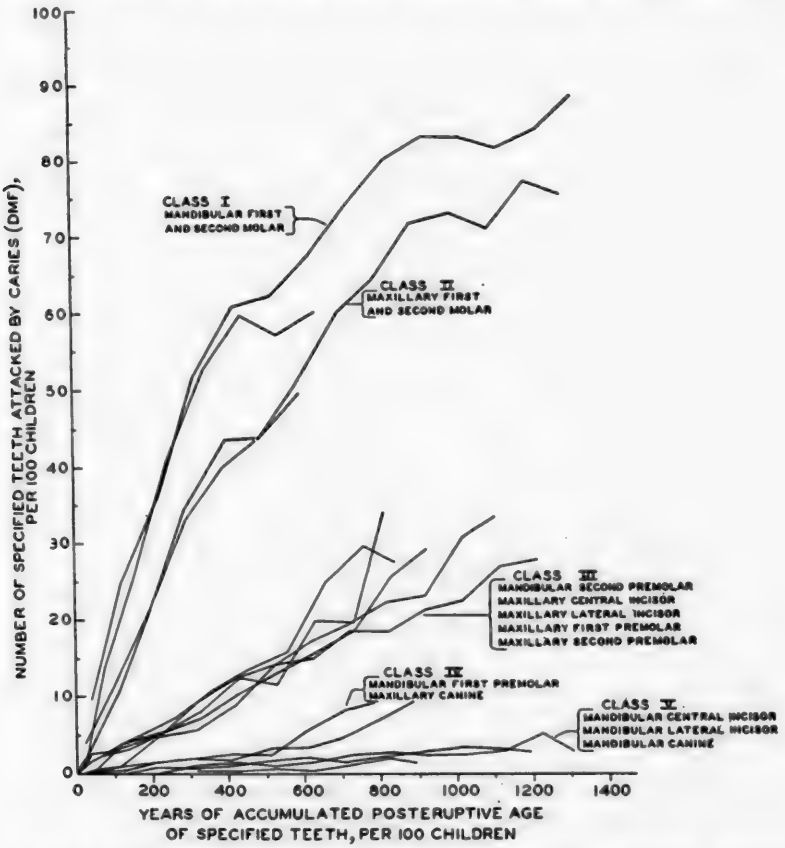

FIG. 1. Particular morphological types of permanent teeth, relationship between duration of posteruptive exposure and caries attack.

Posteruptive Tooth Age. The posteruptive tooth age values for the children are shown in Table III for the separate chronological age groups. These values are obtained as *one-half* the number of years, per 100 children of the specified ages, that each of the pairs of teeth (right and left) has been exposed posteruptively. For example, the number "44.53" shown near the bottom of the first vertical column on

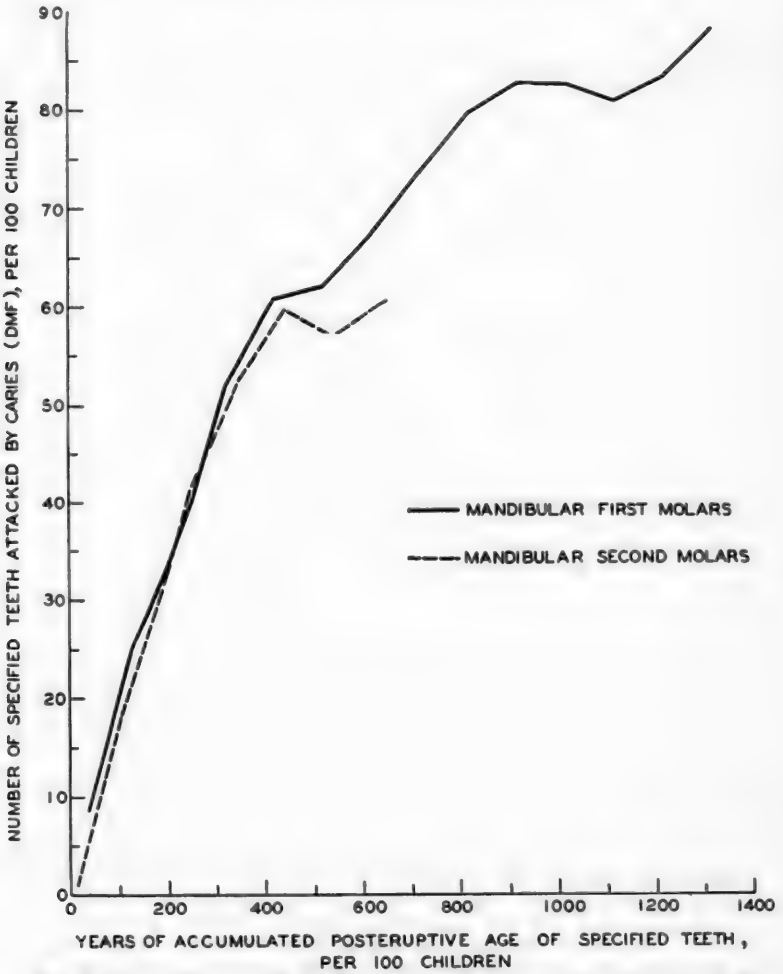

FIG. 2. Class I. The mandibular first and second molars, relationship between duration of posteruptive exposure and caries attack.

the left of Table III represents one-half the estimated number of years, per 100 boys and girls 6.5 years of age, that the left and right mandibular first molars have been exposed in the mouth.[2] The post-

[2] The tooth ages shown in Table III are estimated at exact chronological age points. These values represent the posteruptive ages of particular teeth per 100 children whose ages are exactly 6.5 or 7.5 years and so on. In this respect, the tooth age values differ

eruptive ages of the other teeth in the permanent dentition are obtained similarly. Thus, the tooth ages given apply to particular teeth of

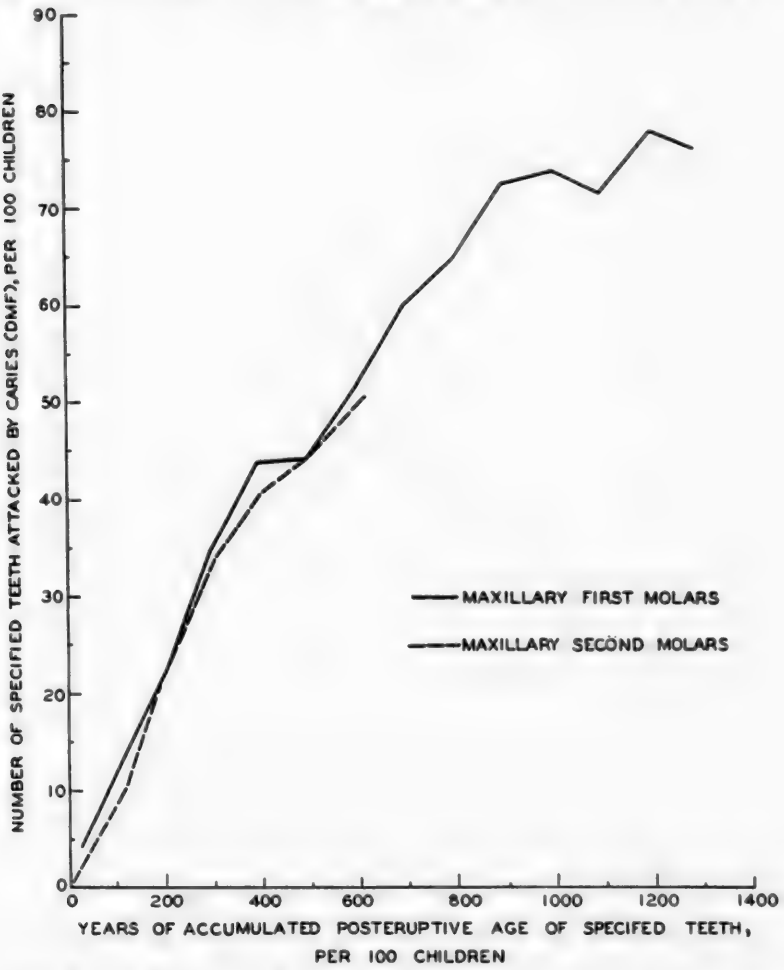

FIG. 3. Class II. The maxillary first and second molars, relationship between duration of post-eruptive exposure and caries attack.

slightly from the caries-experience rates shown in Table II since the latter are derived from groups of children whose ages range over 1 year, that is, between 6 and 7, or 7 and 8 years, for example. The *average* age of the children in these groups is, therefore, considered to be 6.5, or 7.5 years, as the case may be.

either the right or left side of the mouth. The data are given in this form since it has been shown that the right and left members of the pairs of teeth have the same age distribution of eruption (9, 10).

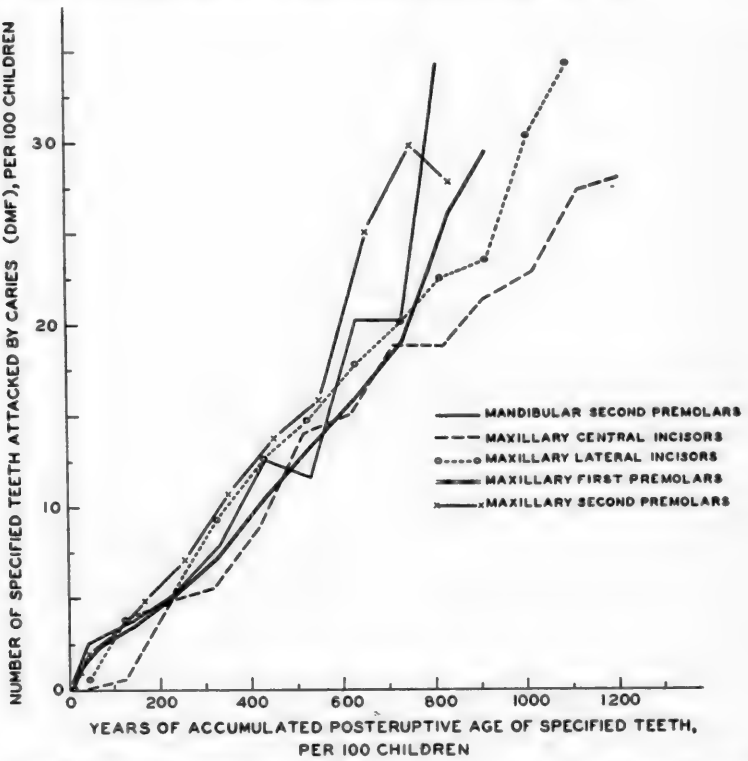

FIG. 4. Class III. The maxillary first and second incisors, first and second premolars and the mandibular second premolars, relationship between duration of posteruptive exposure and caries attack.

Comparison of Tooth-specific Caries Susceptibility. Comparison of the susceptibility of the several permanent teeth may be obtained by relating the DMF rates given in Table II with the posteruptive tooth age values shown in Table III. The results of this procedure, presented graphically in *fig. 1*, give information on the number of particular types of teeth affected by caries experience for given dura-

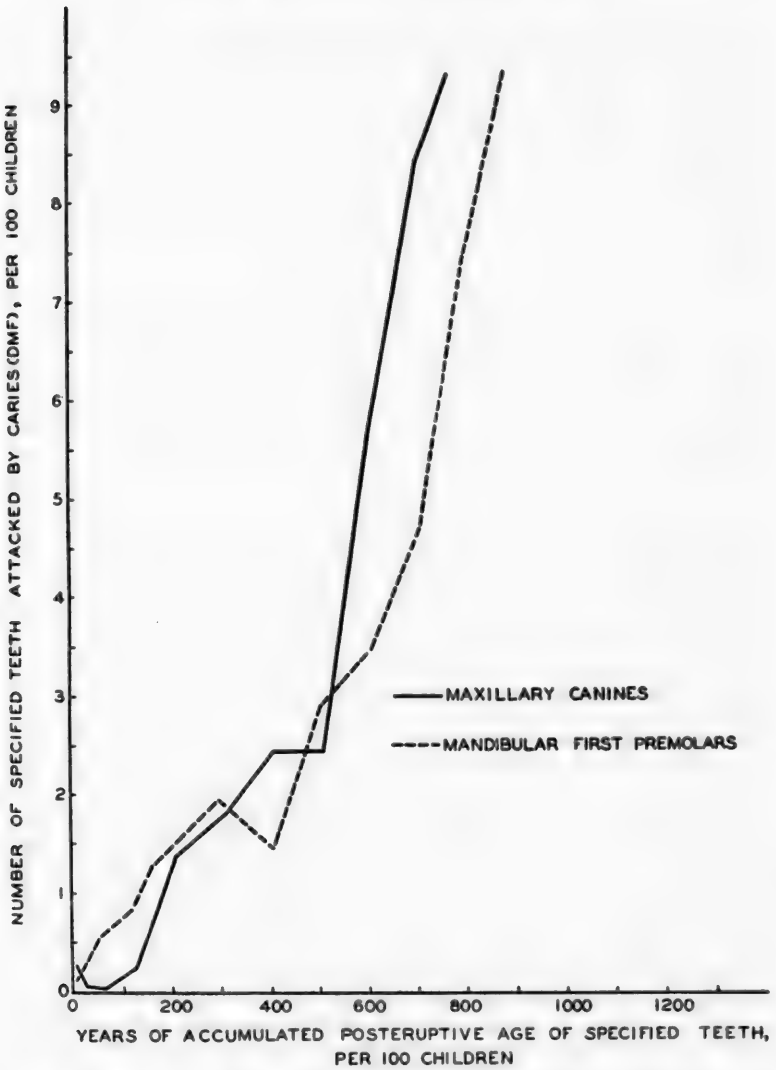

FIG. 5. Class IV. The maxillary canines and the mandibular first premolars, relationship between duration of posteruptive exposure and caries attack.

tions of accumulated posteruptive exposure in the mouth. It is evident that the 28 permanent teeth (third molars are excluded in this study) fall into 5 classes of caries susceptibility. These are, in descending order of susceptibility:

Class I. Mandibular first and second molars.

Class II. Maxillary first and second molars.

Class III. Mandibular second premolars, maxillary first and second premolars, and maxillary first (central) and second (lateral) incisors.

Class IV. Maxillary canines and mandibular first premolars.

Class V. Mandibular first (central) and second (lateral) incisors, and mandibular canines.

The marked similarities in the caries susceptibility of the different teeth included within the individual classes are made evident through plotting the data in the form shown in *figs. 2, 3, 4, 5,* and *6.*

DISCUSSION

The implications of the findings given in the present report are not all immediately apparent. Position of the teeth in the mouth is one factor which appears to be related broadly to the class differences in caries susceptibility. Mandibular and maxillary first and second molars, which are located most posteriorly in the mouth, form the 2 most susceptible classes. On the other hand, the mandibular incisors, canines and first premolars, and the maxillary canines, all but the last of which are located in the lower anterior region of the oral cavity, are included in the 2 least susceptible classes. The teeth having an intermediate level of susceptibility, such as the maxillary incisors and premolars and the mandibular second premolars, except for the last named type, are located in the upper anterior region. The marked resistance of the maxillary canines, in spite of their location in an area of intermediate susceptibility, is worthy of note. The intermediate order of susceptibility of the mandibular second premolars would appear to be consistent with the differences in susceptibility between teeth located in the posterior and that of those in the anterior region of the lower jaw.

Morphological form of the tooth has received some attention as a factor determining the relative susceptibility of particular teeth to caries attack. This opinion arises out of the observation that the most vulnerable teeth (the molars) are those which have deep pits and

fissures in which food debris may be trapped. However, the premolars also have deep pits and fissures, yet other teeth of markedly different morphological form, such as the maxillary incisors, show a caries susceptibility about equal to that of the maxillary premolars. These latter findings would suggest that differences in tooth form, although doubtless a factor in caries susceptibility, are not sufficient to account entirely for the class differences.

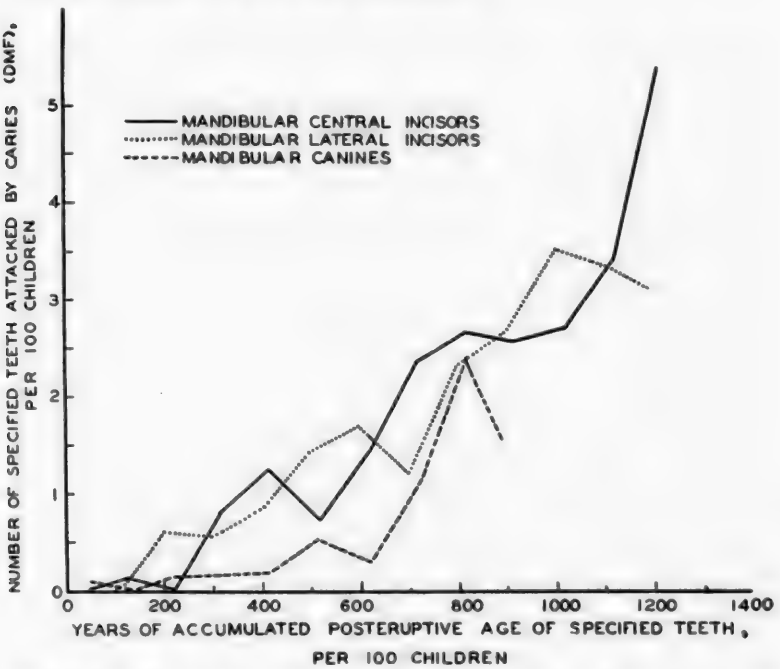

FIG. 6. Class V. The mandibular first and second incisors and canines, relationship between duration of posteruptive exposure and caries attack.

The impression is current that the extreme susceptibility of the first permanent molar is related in some way to physiological and environmental changes occurring during the prenatal state and the period of early childhood. However, the second permanent molars become calcified and erupt at chronological and physiological age levels much different from those at which the first molars erupt; and, subsequent to eruption, the second molars are exposed in the mouth to the risk of attack by caries during a physiological and developmental period which

may be, and probably is, much different than the initial posteruptive exposure which the first molars experience—yet the rate of attack of the second molars is identical with that for the first molars. This finding, when considered in terms of other physiological differences existing during the preeruptive development and posteruptive exposure of these 2 tooth types, leads to the view that perhaps caries attack is controlled also by other factors than the complex of physiological variables operating before eruption, or those existing within particular periods of exposure in the mouth after eruption.

The class differences in the caries susceptibility of the different permanent teeth described in this report have been obtained from observation on a group of children of white American stock attending the schools of communities located in the eastern section of the United States. Comparison of the susceptibility of the permanent teeth of other population groups may give results quite different from those found for the Hagerstown group. That this is the case is suggested by the observations of Dean, Jay, Arnold, McClure and Elvove (13) on a group of white children residing in Illinois, and those of Steggerda and Hill (14) who examined Navajo and Maya Indians and a group of Jamaica Negroes.

The Hagerstown findings serve to demonstrate again the well known fact that caries-resistant and caries-susceptible teeth are found in practically every mouth. It is evident therefore that an epidemiology of the single mouth may be envisioned. Thus, any given mouth may be viewed as a small universe into which is born (erupted) a population of deciduous teeth which flourishes, dies, and is then succeeded by an inflow (eruption) of a population of permanent teeth. For every individual person the several members of this tooth population come into the mouth at different chronological ages and are exposed for various lengths of time to the environment (the mouth) in which caries occurs. Some of the teeth are resistant to caries, others are moderately susceptible, while other types within the same mouth are extremely susceptible. Accordingly, the various rates at which the different types of teeth are attacked by caries serves as a demonstration of the fact that the vectors which produce resistance to caries and those which produce susceptibility exist together in practically every person. The delineation of the epidemiology of caries in the population of teeth

within a single mouth may contribute significant findings in the search for etiological factors in caries.

The considerations given here support the view that the measurement of caries susceptibility in terms of DMF experience and tooth age provides a basic point of departure in epidemiological studies of dental caries. The analysis given in the present paper provides only a preliminary approach to the study of the caries problem in these terms, since only one method of comparing the caries susceptibilities of the different teeth is described. A more detailed comparison could be made available if the DMF rates were expressed as the numbers of particular types of teeth attacked by caries, *per year* of exposure in the mouth. In the language of epidemiology, such values might be called "the tooth-specific tooth-age-specific caries attack rates." To obtain these it would be desirable to fit, by rigorous methods, curves to each of the tooth susceptibility classes shown in *fig. 1.* By finding the mathematical characteristics of such curves the caries susceptibility of each tooth or of each susceptibility class could be precisely defined for the entire period of exposure beginning at the chronological age of eruption. Accurate description of tooth-specific caries susceptibility could also be provided for any particular time interval within the entire mouth exposure of any tooth. Furthermore, caries susceptibility values could be derived for whole population groups or for sub-groups selected on such bases as color, race, economic status, or geographic locality. At the present time such full delineation of the caries susceptibilities of the teeth and tooth surfaces cannot be obtained with the material at hand. Additional caries-experience and tooth-age statistics must be collected for this purpose.

SUMMARY

Epidemiological analysis of dental examination findings on a group of approximately 6,000 school children of Hagerstown, Maryland and environs reveals that the 28 permanent teeth (third molars are not included in the study) tend to fall into 5 caries-susceptibility classes, the different types of teeth included within the single classes showing markedly similar caries susceptibility. The classes are, in descending order of susceptibility:

Class I. Mandibular first and second molars.

Class II. Maxillary first and second molars.

Class III. Mandibular second premolars, maxillary first and second premolars, and maxillary first (central) and second (lateral) incisors.

Class IV. Maxillary canines and mandibular first premolars.

Class V. Mandibular first (central) and second (lateral) incisors, and mandibular canines.

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INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Proceedings of the Nineteenth General Meeting[1]

Jefferson Hotel, St. Louis, Mo.

March 15 and 16, 1940

Compiled by HAMILTON B. G. ROBINSON, *Editor*

Washington University, St. Louis, Mo.

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I. Address of Retiring President

Loyalty to Our Association and to Our Protecting Nation

Wilmer Souder, Ph.D., National Bureau of Standards, Washington, D. C.

The International Association for Dental Research is now in its twenty-first year and has already taken its place in the field of Creative Science. We are well organized. The spirit of cooperation is excellent.

[1] The sessions of the International Association for Dental Research preceded, by agreement, those of the American Association of Dental Schools and Omicron Kappa Upsilon, in the same hotel, March 17–19. The members of each body were welcome at, and participated in, the sessions of the others. The annual informal dinner was served to 128 members and guests, preceding the concluding session.

[2] The Secretary-Treasurer, Edward H. Hatton, has given invaluable aid in compiling these proceedings.

The achievements of the Sections in the United States have been quite satisfactory during the last year if we may judge them by the reports presented during the six sessions of this meeting. All of us have, during the year, endeavored to maintain the ideals of the master International Association, though our thoughts have, at times, been much disturbed and our hearts have been heavy for the welfare of our fellow workers whose lands have been torn by the wars.

Although we in America are extremely proud of our heritage, let us not close our eyes or stop our ears to facts. Reports of well arranged plans to prey upon our Nation and its peoples are becoming too numerous. Reported bold affronts such as the wilful omission of necessary ingredients in published formulas of therapeutic agents developed abroad thus rendering them, when produced here, poisonous to our citizens, or the sabotage of our metal, lens and drug industries by agents living under our protection, should arouse us to a full realization of the fact that these traitors prosper only through our stupidity and credulity.

We of the science and research groups must cooperate with our Government and place at its disposal, as needed, the specialized information and service of our Association. Otherwise how shall our Nation combat the sophistry of enemies operating in our field under the cloak of our professional freedom?

Undoubtedly there are in our Association numbers of individuals who have been fortunate in escaping the iron hand of an autocratic ruler. We are happy to have them with us. They realize the significance of this message and will be found at our shoulder supporting us should our emergency arise. The uncertainties of our Nation's position during the next year compel me to bring this unusual message.

I shall not presume to set up or to suggest next year's program for our incoming president. But let us not be so dignified that we cannot see, hear, discover, interpret or report irregularities in our profession, if such should arise; and more particularly so when millions are now preparing to protect us with their lives if asked to do so. Dignity is not lost or discredited by open eyes, keen ears and alert minds. I cannot retire from this high office without emphasizing these obligations of citizenship and professional liberty.

I have already reported to the Council on the discharge of my official duties as your President. May I repeat some of the more important items to which you have given your approval.

1. The proposition of a friend, who offered to assume responsibility for the publication of our Journal, was investigated. He could offer us little if anything more than we were getting under our own management by our Drs. Robinson, Hall and McCrea. These three loyal workers give their services for the Association freely and are worthy of our continued confidence and support

2. We are now operating under the new Constitution which has been found more satisfactory for the enlarged Association. This new Constitution combines the offices of the Secretary and Treasurer. The Council has secured the consent of Dr. Hatton, one of our most respected members, to assume this double duty for the next year. I have enjoyed my past year's association with Dr. Hatton.

3. The special committee appointed to arrange the details for the Arts and Science Award has completed a nice piece of work. We are indebted to Dr. Robinson, President-elect Schour and Dr. Myers.

4. Then a word of appreciation must be spoken for our sincere friend, Dr. Merrit, and the American College of Dentists. Under the direction of Drs. Gurley and Waugh the College has responded most generously to the Journal Endowment Fund. Without this volunteered support and personal response by the members of the College, we should scarcely have been started on the $50,000.00 endowment fund.

Before relinquishing this position which is supposed to be almost 100 per cent honorary, I want to express my appreciation for the work of other loyal committees. The Local Arrangements Committee, under the guidance of Dr. Robinson, has made our visit most pleasant. Dr. Baker of the Journal Committee and Vice-president Bodecker of the Necrology Committee have each given us dignified reports.

Then I must thank the individual members of the Association for their support during the year. Active members mean vitality for the organization. You have indeed been active.

In a few minutes I shall yield the office of President and ask a repre-

sentative of the Council to proceed with the installation of a worthy successor to whom shall go my best wishes and loyal support.

It shall then be my pleasure to return to the humble position of an active member of the International Association for Dental Research.

II. Introduction of President Elect

Frederick B. Noyes, A.B., D.D.S., Sc.D., School of Dentistry, University of Illinois, Chicago, Ill.

Mr. President, members of the International Association for Dental Research, and guests: It is indeed a pleasure for me to introduce your new President, for we have been very closely associated for more than twenty years; first as teacher and student; then as colleagues on the faculty; and as very close personal friends. Through all of these years our friendship has broadened and deepened and ripened into a very fine treasure. His energy, enthusiasm, clearness of vision, and unfailing loyalty have been a very great inspiration to me.

Certainly your new president most richly deserves the honor you have conferred upon him. I need not rehearse before any research body the contributions of your new president; I have before me a list of eighty odd; a very large number. It is interesting to note, however, that he worked for ten years with very little publication before his studies ripened to the point of presentation. His writing may be grouped under five headings: 1. Vitamins, 2. Endocrines, 3. Metabolism, 4. Growth, and 5. Teaching. During the last few years the study has been more and more concentrated on growth. He has had the wisdom and foresight to associate himself with outstanding investigators by following the dental application of their studies, and has always been able to add much to the work. In this way he has been associated with such investigators as M. C. Smith, H. B. Van Dyke, A. W. Ham, J. M. Rogoft, W. R. Tweedy, F. A. McJunken, S. R. Chandler, R. Kronfeld, E. Roberts, and others, as well as many of the staff of the Colleges of Dentistry and Medicine at the University of Illinois. It is especially important to note that his work has not only added new details to our knowledge of dental structures, but has made notable contribution to broad, fundamental biological concepts.

Beside his research articles, he and Dr. H. J. Noyes have edited, revised, and largely rewritten the *Textbook of Dental Histology and Embryology*, very greatly increasing its value. He has contributed two chapters to *Dental Science* and *Dental Art* and a chapter in E. V. Cowdry's *Special Cytology*, a very important addition to biological literature.

Great as his claim to your recognition is, because of his literary contributions, he is rendering a far greater service to research in developing research workers and stimulating students to study things for themselves. We have perhaps known teachers whose object seemed to be to impress students with the magnitude of their knowledge and the depth of their wisdom from which the students might gather some crumbs, if they could. This man has established a common ground for student and teacher in the examination of the facts. He has been able to awaken in students a desire to answer questions for themselves, which is the foundation of research. Most important of all he has been able to link such a subject as dental histology to the art of dentistry and make students understand that all scientific knowledge has its application if you have the wit to see it. It has been wonderful to see him bring Freshmen students back to the laboratory on Saturday afternoon to answer questions for themselves.

His work has already developed such men as M. M. Hoffman, M. Massler, J. M. Spence, J. W. Adams, R. G. Sarwat, F. Herzberg and more whose names do not come to my mind. It is a greater service to research to develop the powers and fire the enthusiasm of a student and investigator than to write many papers. And so I have the honor to present to you your new President, Dr. Isaac Schour.

III. Inaugural Address

The Problem of Integration in Dental Research, Teaching and Clinical Practice

Isaac Schour, D.D.S., Ph.D., School of Dentistry, University of Illinois, Chicago, Ill.

Our secretary, Dr. Hatton, informs me that tradition calls for an inaugural address by the newly elected president on a subject related

to his own research work. Such tradition, then, in my case would call for a discussion of experimental studies in tooth development.

But I wish to assure you that you will not be subjected to the reading of a monograph on histology. There is a problem confronting us that is more important than histology—one of greater common interest to all of us. I should like to talk to you tonight as a teacher as well as a researcher on the problem of the integration of dental research, teaching and clinical practice.

We are gathered here tonight because we have a common bond and purpose—to promote dentistry as a health service. This singleness of interest is in sharp contrast to the multiplicity of methods we have chosen to attain our common goal.

The three foundations upon which the future of dentistry rests are Research, Teaching and Clinical Practice. The group gathered here tonight represents one of the bulwarks of the dental profession—Research. But I see among us also teachers, administrators and practitioners—in the persons of research workers.

Research has made rapid strides, but unfortunately most of its effort has been directed to *analysis within highly specialized fields*, rather than to *synthesis of all* toward the promotion of dentistry. We have cut up our special fields of interest into smaller and finer components and pieces, and narrowed our vision, forgetting at times that these pieces have to be put together again in the teaching and practice of dentistry. As individuals we have come to "know more and more about less and less." We have attained such a highly specialized division of labor that our scientific language is becoming more and more technical. Soon we shall need expert translators and interpreters at our research meetings.

The rapid progress in research confronts us with a problem and a challenge—to integrate the various special fields of dental research, to consolidate our outposts and to bring together into a more cohesive whole our increasingly diverging fields of endeavor.

The problem of integration in research is closely related to the problem of integration in dental education. The research worker is also a teacher—whether he teaches formally at a dental school or informally through his writings, presentations or clinics. An examination of the traditional teaching that is usually followed shows that the teacher of

the preclinical subject too often confines his interest to pure research whereas the clinician restricts his interests only to applied researches. Therefore, in dental education (as well as in medical education) there has been created an entirely artificial separation (sometimes even a barrier) between preclinical and clinical instruction. Because of this lack of integration, dental training has become incomplete and inconsistent. The head and the hands too often have not been trained or encouraged to work together. There has developed the false conception that thinking and doing are entirely separate processes. Mental superiority or curiosity has been suspiciously regarded as conducive to dental or technical inferiority and dullness. Too many times have clinical instructors looked with unmistakable disfavor upon the student who still showed active interest in his nonclinical subjects.

The student often passes through four years of training with only one or two rare instructors who will attempt to integrate and help him to coördinate his brain and his hands. Too often his instruction consists of isolated, uncorrelated facts or procedures which the student pigeonholes mentally or manually for examinations rather than for use.

In 1929 I tried to point out that "one of the common problems in teaching preclinical subjects is that of correlation. The responsibility for correlating the subjects of a given curriculum must be shared equally by all departments. Preclinical teaching should anticipate clinical instruction. Clinical teaching, in turn, should be based on facts observed and studied in the preclinical courses. Intelligent association of two subjects affords reciprocal value to both. The efficacy of correlation is definitely limited by the time allotted to the course, by the scope of the student's knowledge, by the amount of coöperation among the departments concerned, and by the extent to which the instructor has mastered not only his own subject, but also the subjects with which his course is associated. For the sake of simplicity, correlation may be classified into three types: (a) correlation among preclinical subjects; (b) correlation among clinical subjects; and (c) correlation between the preclinical subjects on the one hand and clinical subjects on the other."

How shall we meet this challenge for greater integration? (Of course we could appoint a committee! That is an easy and popular way of disposing of a question.)

While there is no one way of solving this problem, there are a number of approaches that will start us in the right direction. Since the success of integration depends upon the proper coöperation of the researcher, the educator and the administrator, it becomes the serious responsibility of each to be imbued with the spirit of integration and to promote its development. The responsibility for this much-needed integration rests chiefly upon the teaching faculties in our dental schools, where the researcher and the clinician meet on the same platform as teachers.

The crucial test for the success of integration lies, therefore, with the teacher. A great teacher will teach and inspire, regardless of the disorganization of the curriculum or the inadequacy of the physical equipment. On the other hand, all the rules and regulations, memoranda and instructions, faculty meetings and conferences, will accomplish very little if the teacher lacks the qualifications in personality, intelligence, background and enthusiasm necessary to execute sound principles in education. I have been told of a Curriculum Committee which had been meeting for long hours trying to allocate properly the time available to each subject. Suddenly a member who had been silent throughout the discussion proposed a simple solution—take the hours from the poor teachers and give them to the good teachers!

What, therefore, are some of the specific qualifications that we as teachers should develop?

One essential requisite in teaching is a broad viewpoint, a broad cultural and intellectual background and a continuous devotion to study and learning. This devotion should be a daily discipline. Our love of knowledge should extend beyond our limited field of responsibility. In our role as investigators, too, we should not lose ourselves in our narrow niche but learn to correlate our efforts with those of others. The purist in his subject or science is in danger of becoming static rather than dynamic. Alexander has aptly emphasized the need for a broad perspective in the following statement: "The true specialist should also be a generalist, and should couple a hawklike perception of essential detail with the breadth of vision of the old-school 'natural philosopher'."

Those of you who have had the patience to read my reports visualize the rat incisor when reference is made to my name. However, I have regarded the rat incisor as only one of the many small images of the human incisor, of the human teeth and jaws and the human organism.

It is also essential that we have a proper perspective of our function. We are training students for the practice of dentistry. My own specific assignment is to teach them histology. But my function is not alone to teach histology but also to teach dentistry through the medium of histology. This point of view does not compromise in the least the subject of histology, but, rather, enhances its scientific discipline because it subjects the findings and interpretations in histology to the test of clinical applications. It is scientifically sound to remove the pulp from the incisor of the rat in order to establish the role of the pulp in eruption. Is it not equally scientific to study the eruption of the human incisor from which the pulp was removed for clinical reasons?

The problem of making our professional teaching more utilitarian is not confined to dentistry alone. This challenge has been thrown to medicine as well. August Krogh, one of the greatest physiologists of our time, in an address before the American Academy of Arts and Sciences said: "I am happy to state that the conception is gaining ground in this country that the teaching of physiology in medical schools has for its object to educate students to become doctors and not to become dabblers in the experimental and theoretical science of physiology, but tradition is strong, and, as I see it, there is still a great deal that will have to be weeded out from physiological curricula in medical schools and a great deal that will have to be put in."

In the dental curriculum, too many courses are being taught without any regard to future dental application. General bacteriology is frequently taught without any attention to dental bacteriology. In many schools physiology is taught for over 200 hours and not a single hour is given to dental physiology (or physiology of the dental apparatus). No wonder that in some fields retention of such knowledge by our students is so low. If we had no occasion to walk for a period of years, we would soon forget how to walk.

There should be no conflict between theoretical and practical studies. They are equally important and it is only their synergetic effect that will make for the best and highest advance of our profession.

John Dewey has pointed out that: "The more theoretical studies do not attain their highest development until they find some application in human life, contributing indirectly at least to human freedom and well-being, while the more practical studies can not reach their highest

practicality save as they are animated by a disinterested spirit of inquiry."

It is obvious that in order to integrate our teachings we must integrate our own background and keep continually abreast with current development. The recognition of the value of integrated knowledge is reflected in the increasing interest in comprehensive examinations for our students. What is beneficial to the student is also good for the teacher and in all seriousness I suggest that before subjecting our students to comprehensive examinations we should in our effort to integrate teaching and research first pass these examinations ourselves.

Fortunately most of our dental teachers have dental degrees, and therefore have personal acquaintance with clinical dentistry. In medicine, unfortunately, preclinical subjects are often taught by Doctors of Philosophy who have no medical training.

The preclinical teacher should fortify his subject with clinical correlations. But it is equally important that the clinical teacher justify his position as teacher and base his technical procedures upon biologic principles analyzed and taught in preclinical courses.

It appears that the clinical teacher has been more neglectful in his responsibility in correlation than has the preclinical teacher. It is therefore gratifying to note the presence in this audience of a number of leading clinicians who are active in research and who carry over their research experience and the scientific method into their everyday teaching and practice.

The question might be raised: "Why should these problems of teaching and clinical correlation be discussed at a research gathering?" The justification for this discussion lies in the fact that the researcher is the father of the teacher and the teacher is the father of the dental profession.

It is therefore essential that the researcher in his role as teacher be conscious of the importance of correlation and integration. The investigator should also be an integrator. Without research, teaching would become sterile. Old knowledge can live only when it can feed on new knowledge. Without research, the profession would stagnate.

The ideal solution of the problem of integration is to have the same teacher teach both preclinical and clinical aspects of the same subject

and to have the researcher work upon both the biologic and clinical aspects of the same problem. When this is not possible, a given department should have on its staff both classes of instructors and researchers in close proximity. Collaborative interdepartmental research is often more feasible than intradepartmental research.

Next in importance to the teacher is the curriculum. The function of the curriculum is to promote the full expression of the growth potential and capacities of the student. Now our problem becomes closely interrelated with that of the administrator.

For the function of the dean is to plan and coördinate the entire educational program. He is in the strategic position of seeing not only the individual trees but the entire forest; and the curriculum is one of his special responsibilities. The curriculum should provide a diet that is balanced and palatable, and one that can be assimilated. It should permit both variety and freedom of choice. There should be some time out between meals. A chemical analysis of the dental curriculum would indicate overfeeding of certain elements and deficiency of other nutriments, especially the minerals and vitamins. These accessory catalytic factors promote and integrate the utilization of the bulk of facts. It seems that a number of our courses give sufficient or even excessive factual material but suffer from avitaminosis, so that the facts do not become vitalized and incorporated in the student's mind.

The recognition of the need for the vitalizing influences that integration affords has led to the organization of integration courses given for the specific purpose of correlation between preclinical instruction and clinical practice. For example, at our dental institution, a course originally taught as pediatrics has been transformed into one in dental pediatrics. This course now embodies within it not only the growth and development of the child as a whole, but also the craniofacial development of the jaws and teeth and, what is most important, the relation of such knowledge to the practice of children's dentistry, particularly to the diagnosis and prevention of early malocclusions.

But, while the development of correlation is encouraging, the logical and ultimate solution of the problem lies not in single correlation courses but, rather, in correlation in every course. No doubt we would agree that an adequate vitamin supply should be available in

our daily food and not merely on Sundays or vacations. Similarly, correlation should not be a special dish at a rare and particular occasion. Still it is granted that vitamins on Sundays only are better than none at all.

I hope I shall be pardoned if I cite from personal experience and experimentation. In the teaching of dental histology to our freshmen, only half of the time is spent with the microscope. The other half is devoted to viewing gross specimens, radiographs and—believe it or not—the patient himself. In most instances the patient is the student. The students look not only into the microscope but into each others' mouths. Common developmental disturbances such as enamel hypoplasia, peg laterals, supernumerary teeth, mottled enamel or white spots are easily demonstrated in the mouth of the student. The student's improved power of observation, developed through microscopic examination, is immediately transferred to gross observation. The student is encouraged to work on special projects and is urged to reason, to think, to question and to associate. Full-mouth intraoral radiographs are available to each freshman. He is given the opportunity (which he gladly takes) to examine the radiographs of his own teeth and to search for some of the structures and relationships which he sees in the microscopic section. The blood supply of the gingivae and the lips is studied in microscopic sections; but in addition it is demonstrated in the student's own mouth by means of the capillary microscope which shows the circulation of the blood as well.

Clinical microscopy is taught as well as pure histology. The emphasis in teaching is not only on the scientific discipline of facts and the scientific method of analysis, but also upon clinical correlation and preparation for the practice of dentistry. We are proud of the opportunity to participate in the teaching of dentistry and to stimulate the students' special interest in the dental phases of the basic sciences.

With the introduction of clinical correlations into our course in histology, the content of the course has become much fuller and richer. Teaching has become more efficient and enjoyable. Retention of knowledge has increased, not by memorizing but by the principle of association. Through the method of correlation the students will develop the habit of reasoning and will continue to think throughout their clinical years in terms of the basic biologic sciences. Yet,

surprisingly enough, with the more efficient and intelligent utilization of the time allotted to the course, and with the increased emphasis not merely on facts but on understanding, it has been possible to teach our students more in less time.

I believe that this experience in dental histology throws a refreshing light on the problem of the curriculum. The problem is not the number of hours we have but how we utilize them. The inefficient use of teaching hours is not corrected by additional hours or additional courses. It is gratifying to note that in the recent standards set by The Council of Dental Education the maximum hours for the four-year dental course have been limited to 4400, although a number of schools have been teaching many more hours.

Our dental curriculum has become overspecialized. Isolated and unrelated courses have developed without being tooled to fit one another. The Tree of Dental Education needs scientific pruning. It may be against tradition to eliminate courses, but the authority of logic is stronger than that of tradition. It seems that with the tendency for overdepartmentalization there has been an unnecessary increase in various courses and that the organization of a basic course in the principles of technique should facilitate and expedite their application to particular clinical procedures.

Just as the tooth develops not by a mere piling up of its cusps but unfolds by the harmonious fusion and integration of its individual growth centers, so our multiple research efforts and our curricula should culminate into more than the mathematical addition of the separate parts—but into an integrated unit. Such unity would afford our researchers, our teachers, and our students a growth experience that would expand year by year like a progressive spiral.

As researchers, we should not forget that we are teachers; as clinicians, we should not forget that dentistry can be advanced only through constant and conscientious researches; and as teachers we should remember that the future of dentistry as a profession and a health service depends upon us—through the medium of our students. Therefore we must never forget that we should be researchers as well as clinicians.

Integration has been accomplished historically mainly by the efforts of single great individuals like Sir John Tomes or G. V. Black. Ac-

tually they represent and epitomize the efforts of their many contemporaries without whose achievements their contributions could not have been made.

But we cannot wait for and depend upon genius. We must depend upon concerted and continuous effort. By encouraging integration, by advancing our understanding through research, and by stimulating the imagination of our students and teachers, we furnish the favorable climate and soil for the seeds of progress to grow and blossom.

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V. First Session: Morning, March 15; Abstracts 1–11

1. Osteosclerosis of jaws. *William H. Bauer, M.D., D.D.S., and L. R. Main, D.D.S., School of Dentistry, St. Louis University, St. Louis, Mo.* Radiographic evidence of more or less circumscribed areas of condensed bone surrounding vital teeth automatically discards the opinion that these areas are always associated with non-vital teeth. These radiographic findings were substantiated by microscopic studies of sections through human jaws which showed that these sclerotic areas are a product of a long standing mild inflammation, or generally speaking, of any chronic mild irritative factor. Such factors stimulate osteoblastic activity to such an extent that wide areas of the surrounding bone take on a condensed appearance. The bone marrow is converted into fibrous tissue and the cells of the endosteum deposit an excessive amount of bone. Since, on the one hand, osteosclerotic changes of jaws are not frequent findings, and yet on the other, we find that chronic irritations due to various factors are evident in many jaws without sclerotic changes, we feel that there must be a peculiar predisposition of the individual to this local excessive production of bone. This hypothesis may be justified by referring to the importance of a predispositional factor in keloid formation. (To be published in *J. D. Res.*).

2. Development of fibers in human dentin. *Gerrit Bevelander, Ph.D., of College of Dentistry, New York University, New York, N. Y.* The origin and structure of the fiber system of human dentin was studied in several successive developmental stages of the tooth. Sections were stained with silver and examined by means of polarized light. This study shows (1) reticular fibers derived from the reticular membrane and the pulp becomes oriented in a radial direction, (2) these fibers extend from the pulp to the dentino-enamel junction. In the latter region the fibers are coarse and extremely argyrophylic, (3) as calcification proceeds, some of the fibers undergo a rearrangement appearing at eruption in a transverse or tangential direction in reference to the dentinal tubules. Observations made on

mature specimens show that the peripheral zone retains its embryonic characteristics. The fibers in the pulpal zone retain an arrangement similar to that observed in the new born. They are, however, much more extensive and exhibit very little affinity for silver.

3. IN VITRO AND IN VIVO EXCHANGE OF PHOSPHORUS BY ENAMEL AND DENTIN. *Cyrus Barnum, Ph.D. and W. D. Armstrong, Ph.D., M.D., The Laboratory of Dental Research, University of Minnesota, Minneapolis, Minn.* Four cats received, by subcutaneous injection, potent doses of radioactive phosphorus and were sacrificed on the 5th day. The activity of the enamel was only slightly altered by several repurifications indicating absence of significant amounts of dentin in enamel fraction. The relative amount of radiophosphorus in one gram of ash were: enamel, 5.35; dentin, 69.4; diaphysis, 100; epiphysis, 360; and marrow, 2300. A part, but not all, of ^{32}P in enamel is derived from the saliva. Human teeth treated *in vitro* with saliva containing ^{32}P exchange small, but measurable, quantities of phosphorus through the enamel to the dentin and also through the root dentin *via* the crown dentin to the enamel.

4. EXTERNAL ACQUISITION OF FLUORINE BY ENAMEL. *R. W. Norvold, B.S., D.D.S., J. H. Inglis, D.D.S., and W. D. Armstrong, Ph.D., M.D., The Laboratory of Dental Research, University of Minnesota, Minneapolis, Minn.* It is generally recognized that an optimum amount of fluorine in teeth lessens their susceptibility to decay. The safest and most practical method for increasing the fluorine content of enamel thus far suggested is a topical application of soluble fluorides to the teeth. Several studies have given indirect evidence that this method is feasible. Direct evidence was obtained in an experiment in which 36 sound teeth were divided at random into three groups of 12 each. The roots were covered with collodion and the teeth of group A were immersed for 100 minutes in a sodium fluoride solution containing 1000 p.p.m. of fluorine; those of group B, in a similar solution for 200 minutes; while those of group C were used as a control. The teeth were washed in running water for 24 hours after which the crowns were extracted with fat solvents and the enamel separated from the dentin. The enamel of all teeth of each group was pooled and fluorine analyses were performed upon each group. The results

of repeated analyses showed the enamel of groups A and B to contain 9 per cent and 15.9 per cent more fluorine respectively than that of the control group. The differences in the fluorine content of the group were shown not to be due to analytical variations.

5. MUSCLE TONUS AND TOOTH POSITION. *T. D. Speidel, D.D.S., M.S., College of Dentistry, University of Iowa, Iowa City, Ia.* Many persons with deficient eruption of posterior teeth and consequent large incisor overbites seem to have greater muscle tonus. An attempt to objectively verify this clinical observation produced data which are inconclusive. Forty-three male adults, aged 19 to 27 years, whose teeth, when examined in centric occlusion showed all permanent teeth present (disregarding third molars), correct mesio-distal relationships of the posterior teeth, and contact between the upper and lower incisors, were studied. The overbite was measured directly and ranged from 0.5 mm. to 6.0 mm. Muscle tonus, determined by analyzing kymograph tracings obtained using the technique described by McKinley and Berkwitz, ranged from 5.9 mm. to 129.1 mm. These values were fairly normally distributed throughout the ranges. Correlation of these values by plotting a scattergram and calculation of the coefficient of correlation (0.2881) showed but a low degree of correlation. A few of the persons tested had large overbites and correspondingly greater muscle tonus values. Some persons with small overbites had correspondingly less muscle tonus. However, there were many exceptions to this trend. If the techniques used accurately measure variation in muscle tonus and vertical tooth position, muscle tonus may play a part in influencing these tooth positions but there apparently are other active factors which were not adequately considered in this experiment.

6. DOES THE MAXILLA LACK A PERIOSTEAL MEMBRANE? *L. F. Edwards, B. A., M. S., Ph.D., and P. C. Kitchin, B. S., M. S., D.D.S., College of Dentistry, Ohio State University, Columbus, Ohio.* In order to test the validity of the statement which occasionally appears in the literature concerning the absence of periosteum on the maxilla, gross dissections and histological preparations of this bone were made. These procedures disclosed an investing membrane which, although very loosely connected with the bone, was provided with a

vascular network and its innermost layer contained fibroblasts (potential osteoblasts?) typical of adult normal periosteum. (To be published in *J. D. Res.*)

7. ANATOMY (MICROSCOPIC) OF THE SALIVARY GLANDS OF THE RAT. *Virgil D. Cheyne, D.D.S., Ph.D., School of Dentistry, Indiana University, Indianapolis, Ind.* The salivary glands of the rat are similiar in many respects to those of man. Macroscopic features have been reported previously (J. D. Res., **18:** 457, 1939). The alveolus is the secretory unit and, in the principal glands, many are congregated into lobules which comprise lobes. The excretory system is made up of branching ducts, smaller ones starting as intercalated ducts lined with flat spindle-shaped epithelial cells. In larger ducts epithelium is psuedo-stratified. Stenson's duct empties the parotid, Wharton's the submaxillary and an independent duct the major sublingual. The minor sublingual has several independent openings, ducts of Rivinus. The alveoli of the parotid consist of typical polyhedral albuminous cells, with zymogen granules between the nucleus and secretory end. The submaxillary gland is mixed and 4 cell types can be demonstrated: (1) typical albuminous cells, (2) duct cells (epithelial), (3) atypical mucous cells, and (4) one which resembles mucous cells but reacts differently to special dyes. Phloxine-methylene blue stain, following Zenker's fixation, in this latter type, discloses large and small brilliant blue cytoplasmic granules which are not seen with hematoxylin-eosin. This cell probably represents a poorly differentiated duct cell which does not possess all features of the mucous cell of more advanced mammalian orders. The major sublingual gland is predominantly mucous with occasional albuminous cell crescents. The outlines of the mucous cells are indistinct; classical wide-meshed network of precipitated mucigen is conspicuous in fixed preparations. The nucleus is usually at the cell base in the full state. Albuminous cells are small and few. In the minor sublingual glands the secretory portions are long branching tubules containing only mucous cells.

8. IDIOPATHIC RESORPTION OF TEETH. *Edward C. Stafne, D.D.S., Charles H. Slocumb, M.D., M. S. in Med., Mayo Foundation, Rochester, Minn.* A series of 200 resorbed teeth and the 179 patients who had them were studied. Resorption appears primarily to attack the

dentin and may originate from either the inner or outer surface. This form of resorption has been reported by Miller, Mummery, Mueller, Applebaum, Thoma and others. The incidence of resorption was greatest in anterior teeth, but in cases studied, all teeth were affected except upper molars. Seventeen persons had 2 resorbed teeth each and 2 had 3. The majority of the teeth were vital and free from caries. It is difficult to determine origin from roentgenographic evidence. In 5 instances in which resorption appeared to be confined to pulpal side, the extracted teeth revealed openings to the surface of the root. In 9 teeth studied microscopically resorption and, in most instances, a deposition of osteodentin could be seen. Resorption tends to progress through dentin parallel to the long axis of the tooth; that part of the dentin proximal to the pulp and cementum are more resistant and are destroyed only when resorption is extensive. Twenty-three teeth in which resorption had occurred have been observed repeatedly in roentgenograms for from 1 to 13 years. In some, resorption appears to have been arrested and in others, it has progressed. One tooth was lost as a result of resorption. A review of findings on general medical examination of patients studied revealed that resorption was not associated with any particular systemic condition. A control group in which resorption was not present presented similar physical findings.

9. STUDIES ON THE BACTERIOLOGY OF SUPPURATIVE PERIODONTITIS. *Elizabeth S. Hemmens, B.S., Walter G. Zoller Memorial Dental Clinic, University of Chicago, Chicago, Ill.* Stained smears and anaerobic blood agar cultures have been made of material from suppurating periodontal pockets (39 cases) and from normal gingival crevices (21 cases). Anaerobic, proteolytic microorganisms, such as fusiforms, spirochetes and *Bacterium melaninogenicum*, were more common in pyorrhetic lesions than in normal mouths, but no species was exclusively associated with the process. Subcutaneous inoculation of pus from periodental lesions into normal animals and a "vitamin M" deficient monkey produced localized lesions which healed rapidly and could not be maintained in further animal passages. Scorbutic guinea pigs, similarly inoculated, usually died within a week with a spreading phelgmonous process. Infection was transferred from scorbutic animals through normal guinea pigs with progressively in-

creasing virulence and decreasing complexity of flora until, after the seventh passage, it has reached a stable association which has not varied through 18 subsequent passages. The persisting microorganisms include *Vibrio sputigenus*, several types of cocci, *Bacterium melaninogenicum*, an unidentified fusiform, a gram positive filamentous rod and a spirochete resembling *Treponema microdentium*. Efforts have been made to isolate these forms in pure cultures which, in some cases, have failed, and it is not known whether the flora could be simplified further and full virulence be maintained.

10. THE EFFECT OF ACUTE VITAMIN A DEFICIENCY ON THE MOLAR TEETH AND PARADONTAL TISSUES, WITH A COMMENT ON DEFORMED INCISOR TEETH IN THIS DEFICIENCY. *Paul E. Boyle, D.M.D., and Otto A. Bessey, Ph.D., Dental and Medical Schools, Harvard University, Boston, Mass.* Acute vitamin A deficiency was produced by restricting vitamin A intake of mothers during pregnancy and lactation. Offspring, weaned at 21 days and placed on deficient diet, uniformly develop hind-leg paralysis at about 40th day and seldom survive more than 80 days. Histological examination reveals typical findings including marked retardation of dentin formation on cementum-covered part of incisor teeth (Wolbach and Howe, *Am. J. Path.*, 1933). With few exceptions, gingival tissues of molar teeth are normal. Occasionally pocket formation (with hyperkeratinized crevice epithelium) exposing root is found. The periodontal membrane is greatly widened except in a few instances where molar teeth appear to have been impacted on crest of interradicular bone or on concave surface of curved roots. The alveolar bone is atrophic. Irregular bone resorption with osteophyte formation is found most strikingly on tooth side of buccal alveolar crest. Corresponding tooth root surface almost invariably shows extensive resorption of cementum and underlying dentin. Alveolar bone between apices of molars and lower incisor tooth may show infractures. Postnatally formed root dentin shows localized areas of retarded deposition which usually occur near apex, on sides of roots toward interradicular bone, or opposite areas of impingement of alveolar bone on cementum. Odontoblasts in these areas are atrophic and predentin is absent. Location of these areas of cessation of bone and dentin deposition appears to be determined by mechanical factors. It is suggested that mechanical factors are likewise important in caus-

ing retardation of dentin formation on cementum-covered part of incisor which is suspending part of periodontal apparatus of this tooth.

11. MULTILOCULAR CYSTOMA OF THE ECTODERMAL ANLAGE OF THE TOOTH: NOMENCLATURE, HISTOGENESIS, DIAGNOSIS, DIFFERENTIAL DIAGNOSIS AND THERAPY. *E. Kotanyi, Md.D. Texas Dental College, Houston, Tex.* The number of ameloblastomas in the literature increased from 27 (Winter, 1922) to 379 (Robinson, 1937) in 15 years. This increasing number of cases secured a better knowledge about these not so "infrequently" occurring tumors (Darlington). A great handicap of further development is, and has always been, either a conscious or unconscious failure to recognize proven facts in previous references. Our most urgent duty and problem, now, is as much histological as clinical. The failure to establish the proper correlation between these components has far reaching consequences for the patient. We have a clearer conception of the histogenesis of the ameloblastoma by using Schour's terminology for development of teeth. In doing so we can tell that the tumor forming cells retained fully only their potentiality of proliferation (cell division), but they lost their former ability of histo or cell differentiation, to some extent, and fully their ability of apposition or additive extracellular growth. This is the reason why we have no dentin and consequently no enamel formation. Some cylindrical cells of the ameloblastomas, even when present, never form enamel, therefore it would be better to call these tumors, multilocular cystomas (that is the usual clinical appearance) of the ectodermal anlage of the tooth. A case was described which was operated on by Pichler's method after 9 years, no recurrence was found. Attention was called to the fact that an apicotomy-like resorption of the apex in connection with cystic formations indicates a neoplasm rather than a cyst. On account of the good results with the conservative method of operation (Pichler) in 45 cases, it is without any question that there is seldom a necessity for resection of the jaw in cases of multilocular cystoma of the ectodermal anlage of the tooth.

VI. SECOND SESSION: AFTERNOON, MARCH 15; ABSTRACTS 12–23

12. DOMESTIC WATER AND DENTAL CARIES. II. A STUDY OF 2832 WHITE CHILDREN, AGE 12–14 YEARS, OF 8 SUBURBAN CHICAGO COMMUNITIES, INCLUDING *Lactobacillus acidophilus* STUDIES OF 1761

CHILDREN. *H. Trendley Dean, D.D.S., Philip Jay, D.D.S., M.S. (School of Dentistry, University of Michigan), Francis A. Arnold, Jr., B.S., D.D.S., and Elias Elvove, M.S., Phar. D., Ph.D., Division of Infectious Diseases and Division of Chemistry, National Institute of Health, U. S. Public Health Service, Washington, D. C.* Epidemiological study relation of fluoride domestic waters to dental caries experience made in 8 relatively homogeneous urban populations of suburban Chicago. Diagnostic standards calibrated and in each community number of children examined by each of 2 examiners equal. Study groups consisted of all 12, 13, and 14 year old white public school children in 7th, 8th, and 9th grades who *had been exposed continuously to variable under investigation* (common water supply). Unlikely any gross dietary differences (exclusive of water) between children of Maywood and Oak Park (within 1 mile radius) or dietary regime of 633 Aurora children sufficiently different from 423 Waukegan children to produce differences in dental caries experience of 281 to 810 per 100 children examined. Most pertinent finding was disclosure that water supplies, fluoride concentrations of which not far from minimal threshold of mottled enamel, 1.0 p.p.m. of F. (e.g., Aurora, 1.2 p.p.m.) were associated with unusually low dental caries experience rates. Thus, dental caries inhibitory factor, presumably present in water and probably fluoride, operatives at levels where mottled enamel per se is of minimal public health and no aesthetic significance. (Published in *Public Health Rep.* **56:** 761, 1941.)

13. OBSERVATIONS ON INDUCED DENTAL CARIES IN RATS. III. QUANTITATIVE RELATIONS OF EFFECT OF FLUORINE ON RAT CARIES, AND DATA REGARDING COMPOSITION OF MOLAR AND INCISOR TEETH. *F. J. McClure, Ph.D., National Institute of Health, U. S. Public Health Service, Washington, D. C.* Quantities of fluorine equalling 5, 10, 50, and 100 ppm. in the drinking water were studied for their effects on induced occlusal caries in rats and on the composition of the teeth. The relative caries prevention which occurred from various levels of fluorine indicate its action to be anti-enzymatic in nature. Ten parts per million of fluorine gave prevention against caries, but may represent borderline protection under conditions of this experiment. The addition of fluorine to the rats' diet brought about proportional increases in the fluorine content of the dentin and enamel. This fluorine

was added following the formation of the molar teeth and caused no macroscopic evidence of dental fluorosis, i.e., mottled enamel. The calcium, phosphorus and ash in the pooled definitely carious molar teeth of groups of rats was no different from that in the pooled non-carious molar teeth of groups of rats. No significant differences were shown in the limited data obtained in content of fluorine either in the molar dentin or enamel of carious and non-carious rats.

14. OBSERVATIONS ON INDUCED CARIES IN RATS. II. THE EFFECT OF SUBCUTANEOUS INJECTIONS OF FLUORIDES. *Francis A. Arnold, Jr., B.S., D.D.S. and Frank J. McClure, Ph.D., Division of Infectious Diseases, National Institute of Health, U. S. Public Health Service, Washington, D. C.* Litter mate rats, more than 30 days old, were distributed into three groups: 23 controls, 20 fluoride water, 24 injection. All rats were given a caries producing diet. The injection group received subcutaneous injections of 0.5 mg F as NaF and evidence is presented to indicate that the absorption of F was comparable to that from water containing about 50 ppm. F, an amount which has been found to inhibit the production of dental caries. The fluoride water group received drinking water containing 10 ppm. F as NaF. The amount of "macroscopic" dental caries was determined and the enamel and dentin of the incisor and molar teeth were analyzed for ash and fluorine content. The results indicate that: 1. Subcutaneous injection of sodium fluoride produced no significant reduction in induced dental caries. 2. The fluorine content of the enamel and dentin of incisor and molar teeth of rats was increased both by injection of NaF and by water containing NaF. 3. The action of fluorine on induced rat caries is more closely related to local than to systemic influences. 4. Although the fluorine content of enamel of molar teeth was increased, these teeth did not show any increased resistance to caries attack.

15. FURTHER OBSERVATIONS ON THE FORMATION OF CEMENTUM, PERIODONTAL MEMBRANE AND BONE WITH THE USE OF BOILED COW BONE POWDER. *Frank E. Beube, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* It was observed (*J. D. Res.* **19**: 1940) with boiled cow bone powder placed over roots of teeth, that various changes occurred in healing of connecting and supporting structures of dog's teeth. Further animal experimentation

and study of histological sections, beginning with 24 hours of healing, showed erythrocytes and polymorphonuclear leukocytes profusely infiltrated throughout the bone spicule containing field. There was no cellular activity about the bone chips. In the 3½ day specimen there were signs of an old inflammatory process, with mononuclear and polymorphonuclear leukocytes and histiocytes. Four days later, young tissue repair, with new capillaries, was taking place; new fibroblasts appeared, and bone chips began to show dissolution. Monocytes and histiocytes were still apparent. On the 9th, 12th, and 14th days of healing, an older granulation tissue (fibrosis) was seen with some monocytes and histiocytes still present. The fewer disintegrating bone spicules took on a position where the new alveolar bone would form, unlike the irregular scattering of the powder seen in earlier sections. New granulation tissue was between bone spicules and dentin. By the 17th day new trabeculated bone was laid down with wide Haversian systems and spicules of bone were no longer seen. The dentin was well covered by a layer of osteoid tissue or secondary cementum with imbedded cells.

16. ENAMEL HYPOPLASIA. *Charles F. Bodecker, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* Teeth with hypoplastic enamel tend to discolor somewhat because their roughened surfaces cannot be kept free of stain. This condition, however, occasionally is complicated by a deep, general brownish discoloration of all the teeth. The present investigation deals with such a case in which 32 teeth were removed from a girl of 17 years. The histological examination of this material showed that the enamel contained an abnormally high content of malformed matrix which gave evidence of a disturbance of the pre- and post-eruptive calcification of the enamel. This condition created a pathological permeability of the enamel allowing the entrance of the saliva, thus explaining the deep brownish discoloration of the teeth. This investigation bears out the work of Diamond and Weinmann by giving evidence that 2 pathological conditions existed: 1. enamel hypoplasia caused by an abnormal matrix formation and 2. a disturbance in its subsequent calcification. (To be published in *J. D. Res.*)

17. CONTROL OF BONE CHANGES IN THE SKULL CAUSED BY ORTHODONTIC TREATMENT. *Carl Breitner M.D., D.D.S., School of Dental and*

Oral Surgery, Columbia University, New York, N. Y. It has been established by previous investigation (*Am. Jour. Orth.*, **26:** 521, 1940) that influence of orthodontic treatment is not confined to alveolar process but extends to other parts of skull, e.g., temporomandibular joint, mandibular ramus and angle. Experimental treatment on monkeys was performed to establish whether this influence can be exerted methodically in order to create desirable skull changes. Judicious control of these bone changes seems essential. Thus orthodontic procedure develops into orthopedics or, more specifically, orthognathics. Experiment has revealed that the position of mandible in relation to skull can be changed in a mesio-distal direction without application to teeth of forces acting in this direction. In this manner greatest possible amount of beneficial aesthetic effect can be obtained in some cases. The experiments, in correlation with clinical observation, justify the assumption that the vertical dimension cannot be increased permanently by ordinary orthodontic procedure but is an individual constant at each stage of development. It can, however, be decreased by mutilation, e.g., loss of groups of teeth. This distance is probably the result of a balance between length of masticatory muscles and bone. (Since the length of muscles is practically unalterable orthodontically, permanent increase of the vertical dimension cannot be attained by such means.) Proceeding from this basic knowledge we may attempt to produce permanent changes in bony parts of masticatory apparatus via intermediate changes in vertical dimension.

18. MORPHOGENESIS OF THE AMELOBLAST IN RELATION TO THE ESTABLISHMENT OF THE FIXED DENTINO-ENAMEL JUNCTION. *Moses Diamond, D.D.S. and Joseph P. Weinmann, M.D., Columbia University, School of Dental and Oral Surgery, New York, N. Y.* This study was made to determine the changing border relationships between ameloblasts and peripheral cells of the connective tissue up to the beginning of formation of dentin and enamel. Human tooth germs which presented evidence of beginning dentin and enamel formation in the incisal region of anterior teeth, or occlusal region of posterior teeth, and a much earlier stage of development in the region of the epithelial loop were selected. A series of photomicrographs, taken under oil immersion, of an entire lingual area of a mandibular

first incisor tooth germ from the cervical loop to the incisal region were accurately related and mounted to observe a series of changes in development in sequence. Studies revealed that ameloblasts in undifferentiated state are columnar in form, consisting almost entirely of nucleus with very little cytoplasm. The border cells of underlying connective tissue are undifferentiated mesenchymal cells. Between these adjacent cells, is a fibrous membrane. The ameloblasts then elongate almost entirely by an increase in cytoplasm until contact is made with the underlying connective tissue border cells which differentiate into odontoblasts. At this stage, the first dentin is noted. The first formed dentin is pushed outwardly against the ameloblasts which now present additional morphologic changes and which begin to form enamel in matrix state. At this time, the dentin remains in the location where it is deposited, the connective tissue cells withdrawing inward. The dentino-enamel junction cannot be considered as fixed until the ameloblasts begin functioning to produce enamel matrix.

19. CONCERNING THE "VITALITY" OF THE CALCIFIED DENTAL TISSUES. V. DENTAL LYMPH IN THE DENTIN. *William Lefkowitz, D.D.S., Columbia University, School of Dental and Oral Surgery New York, N. Y.* The passage of dental lymph through the dentin is demonstrated by inserting silver stains in the pulps of human, dog and calf teeth. Small cavities were prepared at the cervix of the tooth for insertion of the dyes. The teeth were stained for periods varying from 2 hours to 6 days. Human deciduous teeth, treated for pulp exposure by pulp capping, were included in this study. The use of silver stains made it possible to prepare decalcified sections without destroying the stains. Staining of the pulp occurred principally in the layer of Weil. In the presence of normal odontoblasts, the stain penetrated selected tubules in the entire body of the dentin. The silver salts accumulated in interglobular dentin. Further evidence of an afferent and efferent flow is presented with a possible suggestion of the mechanism. (To be published in *J. D. Res.*)

20. THE EFFECTIVENESS OF CHILLED BURS IN ELIMINATING PAIN. *B. O. A. Thomas, D.D.S., M.S.*, Columbia University, School of Dental and Oral Surgery, New York, N. Y. A specially constructed

handpiece was used in this study, allowing the evaporation of liquid carbon dioxide to cool the dental bur to a temperature lower than 0°C. Cavities were prepared in 43 teeth of 33 patients. Of these, 24 teeth (55.8 per cent) gave a sharp momentary pain response when the cold bur was first placed against the freshly cut dentin. We found that the use of the cold bur: 1. eliminated the pain in 6 teeth (14 per cent). 2. reduced the pain in 27 teeth (62.8 per cent). 3. did not alter the pain in 7 teeth (16.3 per cent). 4. was more painful in 3 teeth (7 per cent). In other words, cavities were prepared less painfully in 76.8 per cent of the cases when the cold bur was used. The highest temperatures (recorded by means of a thermocouple embedded in the dentin in vivo) for the regular temperature bur varied from 102°F. to 118.6°F., and from 88.8°F. to 95.5°F. for the cold burs. In individual cases the difference in temperature between the cold and regular bur varied between 10°F. and 23.1°F. Histologic sections showed the dental pulp is unaffected by this very localized application of cold to the dentin. (To be published in *J. D. Res.*)

21. EFFECT OF THE MALE SEX HORMONE ON THE GINGIVAE AND ORAL MUCOUS MEMBRANES OF RHESUS MONKEYS AND HUMANS. *Daniel E. Ziskin, D.D.S., Columbia University, School of Dental and Oral Surgery, New York City, N. Y.* The male sex hormone (testosterone propionate) was tested on 6 rhesus monkeys for its effects on the gingivae and oral mucous membranes. Two of the animals were normal males, 2 castrated males, and 2 normal females. Biopsies were taken preexperimentally and at autopsy. Gingival biopsies were taken from a group of humans treated with testosterone propionate for male impotence and persistent uterine bleeding. The changes seen in both groups were uniform throughout. Grossly, the gingivae took on a more healthy appearance. Microscopically, the keratin layer was improved. Keratin was seen on the areolar gingiva as well as the alveolar. Hyperplasia of the epithelium was evidenced by the increased number of nuclei and mitotic figures. The epithelial pegs were broader than normal, bluntly pointed or square. The nuclei stained deeply, and nucleoli and nuclear membrane were prominent. The connective tissue also showed evidence of hyperplasia in density and cellularity. Epithelial curls appeared prominently on the sur-

face. From these findings it was concluded that testosterone propionate produces a stimulating action on the epithelium and connective tissue with a resultant beneficial effect on the gums. (To be published in *J. D. Res.*)

22. CHEMICAL AND HISTOLOGICAL INVESTIGATIONS ON THE DEVELOPING ENAMEL OF PIG'S TEETH. *Joseph P. Weinmann, M.D., George D. Wessinger, Ph.D. and G. Reed, Ph.D., Foundation for Dental Research of the Chicago College of Dental Surgery, Chicago, Ill.* Chemical analyses of various sections of enamel, obtained from an unerupted pig's molar, were made for moisture, organic material, total calcium and total phosphorous. Histological sections were prepared from the corresponding tooth on the opposite side of the jaw, so that the histological picture could be compared with the chemical findings. The following tentative conclusions were arrived at: 1. A portion of the calcium and phosphorous is present in the enamel matrix as it is laid down in incremental lines; it amounts to about one-fourth of that necessary for complete calcification. 2. The phenomenon of calcification—or maturation—begins in the mesial portion of the tooth first. 3. Calcification begins at the highest occlusal point of the tooth and spreads in a cervical direction and does not begin at the dentino-enamel junction and spread peripherally in a plane parallel to the incremental lines as previously supposed. 4. All of the organic portion of the enamel matrix is in the form of protein. 5. During calcification, not only does the calcium and phosphorous increase but organic and moisture content decrease. Further work is in progress.

23. RECOVERY FROM THE REMOVAL OF AN IMPACTED 3RD MOLAR COMPLICATED BY INFECTIOUS MONONUCLEOSIS. *Harry D. Spangenberg, Jr., D.D.S., M.S. in Dent. Surg., Ohio State University, College of Dentistry, Columbus, Ohio.* The uneventful recovery from the removal of an impacted mandibular 3rd molar from a 21 year old female was interrupted by infectious mononucleosis. The first symptom referable to this disease was noted on the 3rd post-operative day. The following subjective and objective symptoms usually described as occurring in cases of infectious mononucleosis appeared and included a high fever (104.5°F.), sore throat, painfully enlarged lymph nodes, edema of eyelids, epistaxis and headache. These symptoms may also accompany acute lymphatic leukemia. The differential diagnosis is made from studies of blood smears in which there are characteristic changes

in the lymphocytes (Downey and McKinlay). Although the etiology of the disease is unknown, "lymphotrophic virus," a protozoan of the genus Toxoplasma, *Bacterium monocytogenes*, *Bacterium monocytogenes hominis* and Vincent's infection have been suggested. The fact that sulfanilamide, sulfapyridine and sulfathiazol administered from the 3rd to the 8th post-operative day did not alter the course of the disease, tends to rule out the organisms usually considered to be affected by this group of drugs. Downey (personal com.) believes that any possible etiologic relationship between infectious mononucleosis and dental surgery is quite unlikely, but suggests that the wound incidental to extraction might have furnished a convenient portal of entry for the organism which may be responsible for the disease. If this were the case, the lymph nodes draining the region of surgery ought to have been involved. These nodes were one of the few not involved. A review of the literature failed to reveal any case similar to the one reported here.

VII. Third Session: Evening, March 15; Abstracts 24–44

(A) Dental Materials Group: Abstracts 24–30

24. A study of excessive expansion phenomena in amalgams. *E. W. Skinner, Ph.D. and J. R. Jarabak, D.D.S., School of Dentistry, Northwestern University, Chicago, Ill.* Angell and Crowell (work not published) have previously demonstrated a secondary amalgam expansion which occurs beginning about the fourth day after trituration. This expansion is usually associated with the incorporation of skin secretion during palming. The observations of Angell and Crowell have been extended in the present study to include the effect of certain variables of manipulation and, to a limited degree, of alloy and amalgam composition. The secondary expansion is absent when the amalgamated mass is not palmed.

25. The hardening time of zinc oxide-eugenol cements. *E. J. Molnar, D.D.S and E. W. Skinner, Ph.D., School of Dentistry, Northwestern University, Chicago, Ill.* The following points were covered: 1. The behavior of various compounds which can be used as accelerators for Zn O-Rosin-Eugenol cements and their effect upon the hardening time. 2. Discussion of oil of bay as a satisfactory substitute for eugenol, retaining the latter's desirable properties and improving the

odor and flavor. 3. Indication of the different constitutents and various other factors, especially the acid content of rosin and their effect on hardening time.

26. TORSION TESTS AND MICROSCOPIC EXAMINATION OF JOINTS PRODUCED BY CASTING TO EMBEDDED WIRES. *F. A. Peyton, D.Sc., School of Dentistry, University of Michigan, Ann Arbor, Mich.* Microscopic examination shows that gold alloys may be successfully cast to embedded wire in partial denture construction to replace the soldered joint in an assembled type restoration. Torsion tests indicate that from 2 to 2.5 mm. of wire is sufficient for good attachment and that greater lengths of wire are superfluous. Torsion tests also show that good union is not established when an investment free of reducing agent to remove sulfur gases is used. This is supported by microscopic examination of the wire and is in agreement with previous studies on this subject. Microscopic examination of the joint broken in torsion shows the twisting action to take place in the wire adjacent to the point of attachment of the cast alloy, rather than within the attached portion of wire. High magnification of the wire shows it to be slightly recrystallized as a result of being embedded and heated for wax elimination. Physical tests of stiffness and 90 degree cold bending show the wire to be unaltered in stiffness when heated but the cold bends are reduced in number from an average value of 6.5 to 5.5.

27. DIMENSIONAL CHANGES IN DENTURES. *G. C. Paffenbarger, D.D.S., National Bureau of Standards, Washington, D. C.* Dimensional changes in dentures may occur: 1. By the release of internal strain, 2. water sorption, 3. water loss, 4. during processing, 5. by long continued curing after placing in service, and 6. by change in temperature. Methods of demonstrating these changes and of measuring some quantitatively were discussed.

28. THE RELATIONSHIP OF THE TENSILE AND BENDING ELASTIC LIMITS OF CAST GOLD WIRES. *K. W. Ray, Ph.D., General Refineries, Minneapolis.* The approximate elastic limit of a casting gold can be determined by empirical methods by testing a small cast wire on the Olsen Stiffness Tester. A few other simple and convenient test methods that might serve for routine acceptance tests on a batch of gold are mentioned.

29. SOME OBSERVATIONS ON THE OLSEN STIFFNESS TESTER. *P. B. Taylor, A. M., Captain, U. S. A., School of Dentistry, Western Reserve University, Cleveland, Ohio.* A series of wrought alloys have been studied, and an attempt made to correlate stiffness data with the regular tensile data. No correlation was found to exist. There seems to be some indication from these observations that the tensile test should be supplemented by some sort of bending test.

30. THE EFFECT OF VULCANIZATION UPON GYPSUM PRODUCTS. *P. B. Taylor, A.M., Captain, U. S. A. and David Bailey, School of Dentistry, Western Reserve University, Cleveland, Ohio.* The strength of gypsum products has been considered in atmospheres of saturated steam at temperatures from 110°C. to 150°C. Observations have also been made in boiling water. Boiling water has no significant effect upon the strength. Temperatures in excess of 115°C. weaken the product considerably in a very short time. Further heating has little effect.

(B) REGULAR EVENING SESSION: ABSTRACTS 31–44

31. BLOOD SUPPLY OF DENTAL PULP. *Leroy R. Boling, Ph.D., Washington University, School of Dentistry, St. Louis, Mo.* The blood vessels of the teeth of cats and dogs were studied by means of cleared injected specimens and by graphic reproduction from serial sections. Five to 8 arterioles were found entering each tooth or each root of 2 rooted teeth. Veins leaving the apex were more numerous, 12 were counted leaving the maxillary third incisor of an adult cat. Within the tooth the arteries remain straight with few major branches. Those entering at the sides of the apex are usually distributed to the pulp of the root, the larger central vessels passing to the pulp chamber and horns. Anastomoses between arteries entering through separate roots may be easily seen in the pulp chamber. These anastomoses were further demonstrated in double rooted teeth with the blood supply removed from one apex. Veins within the pulp cavity form a richly anastomotic plexus but with several large well marked channels running parallel in the roots. The diameter of the veins in the pulp is much greater than of those leaving the apex indicating a sluggish flow within the pulp. Several foramina are found at each apex of a fully formed tooth, some containing vein and artery, some 2 vessels alike and some

with only 1 vessel. In 2 molars arteries were found entering the pulp chambers at the bifurcation of the roots.

32. COMPARATIVE BACTERIOLOGIC FINDINGS OBTAINED FROM THE BLOOD STREAM, VISCERA, GINGIVAL CREVICE, PERIAPEX, ROOT APEX, CORONAL PULP AND THE DENTAL PERIOSTEUM MIDWAY BETWEEN THE APEX AND MARGINAL GINGIVA. *Lester Burket, D.D.S., M.D., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* Comparative bacteriologic studies were made on the above areas of 54 teeth in situ at post mortem. *S. marcesens* was used to determine whether the trauma incident to the removal of the specimen or the culturing procedures forced organisms into the perapical tissues. A similarity in respect to the frequency of positive growths and the types of organisms recovered was observed in the cultures from the periapex and the root apex with the contained pulp. Examinations of the coronal pulp and dental periosteum half way between the apex and the marginal gingiva rarely yielded bacteria. While the results of these few observations permit no definite conclusions as to the avenue by which bacteria may gain access to the periapical region of teeth without marked caries or periodontic involvement, suggestive evidence points to the blood stream as being a factor of significance. (To be published in *J. D. Res.*)

33. SILVER ROOT CANAL FILLINGS—THEIR ADAPTATION AND TISSUE TOLERANCE. *E. A. Jasper, D.D.S, Washington University School of Dentistry, St. Louis, Mo.* Guttapercha has long been a favorite material for filling root canals, and is good when closely adapted to the canal walls. Coolidge, Kronfeld and others have demonstrated that it is readily tolerated, new cementum being deposited immediately adjacent to it. However, since guttapercha readily changes shape under pressure, it is extremely difficult to prevent over-filling when adapting it. The periapical tissues may adjust themselves to impingement, if it is not too great, but the process of healing is complicated and retarded. To simplify this phase root-canal therapy, the author in 1931, had made silver cones which correspond to standard instruments. The fact that root canals present many irregularities and are rarely round was not overlooked. Since canals must be enlarged to clean them, and since this is done with round, tapered instruments, at least the apical portion of the root canal is made round and definitely tapered. These cones conform to such apertures. When a cone has

been fitted, it is sealed in position with a bland compound. Roentgenographic check-ups of 100 cases show apparently complete tissue tolerance in 81. Presumably the failures were due to factors other than the silver, as 76 per cent is the highest degree of success reported for guttapercha canal fillings. (To be published in *J. D. Res.*)

34. ANACHORETIC EFFECT IN PULPITIS. II. HISTOLOGIC STUDIES. *Leroy R. Boling, Ph.D. and Hamilton B. G. Robinson, D.D.S, M.S., Washington University School of Dentistry, St. Louis, Mo.* Histologic studies of the experimental material utilized previously for bacterial study (*J. A. D. A.* **28:** 268, 1941) were reported. Croton oil was applied to the cut dentin in prepared cavities in cats. Subsequently bacteria (streptococci in 13 animals, staphylococci in 5) were injected in hind leg vein. Natural infection was acquired by 18 other cats. Of 32 pulps from treated teeth of streptococcal injected cats 9.4 per cent were normal, 3.1 hyperemic, 6.2 had cellular infiltration, 9.4 had abscesses, 40.6 delimited necrosis and 31 total necrosis. In 16 of these the periodontium was unaffected, 7 had cellular infiltration, 7 abscesses and 5 had connective tissue proliferation periapically. Sixteen untreated teeth had normal pulps. Of 11 pulps from treated teeth in staphylococcal injected cats none were normal, 9.1 per cent hyperemic, 45.5 abscessed, 19.2 had delimited necrosis and 27.3 total necrosis. One of these had normal periodontium, 2 cellular infiltration, 4 abscesses and 1 proliferation periapically. The 8 controls were negative. In the naturally infected cats 12.5 per cent of 40 treated teeth were normal pulpally, 5.0 hyperemic, 12.5 infiltrated, 27.5 abscessed, 20.0 had delimited necrosis and 22.5 total necrosis. Sixteen teeth were normal periapically, 9 infiltrated, 7 abscessed and 1 had periapical proliferation. Two of 29 control teeth had pulpal pathosis. A definite time relationship between infection and type of pathosis was established.

35. ROOT CANAL STUDIES: ANAEROBIC CULTURES. *Fred W. Morse, Jr., M.D., Morton F. Yates, D.M.D. and Vincent J. Fields, Harvard University Medical and Dental Schools, Boston, Mass.* In studies of the bacteriology of root canals we, Sommer, Buchbinder and others, find a considerable number of negative cultures obtained on the initial opening. It seems probable that anaerobic cultures might give a higher percentage of positive results. Anaerobic methods using sodium thioglycollate as an agent for reduction of oxygen have been developed

by Brewer and reported on favorably by McClung. Using several types of media containing sodium thioglycollate and methylene blue as an indicator of the anaerobic state, we have made duplicate cultures from root canals to compare anaerobic media with our old type of media as a control. In a series of 44 teeth investigated, anaerobic cultures showed 16 positive and 28 negative results, whereas the aerobic cultures used as controls showed 22 positive and 22 negative. In 10 instances there was disagreement in results between aerobic and anaerobic cultures. In 7 of these the control cultures gave positive results, while the anaerobes were negative; and in only 3 were the anaerobic results positive and control results negative. This work must be continued, but suggests that negative cultures found on first opening of root canals are to be expected in a certain number of cases and are not due entirely to inadequate bacteriological methods.

36. STUDY OF BACTERIOLOGIC CULTURE METHODS USED IN ROOT CANAL THERAPY WITH REFERENCE TO SODIUM THIOGLYCOLLATE MEDIUM. *Mary Crowley, M.S.P.H., School of Dentistry, University of Michigan, Ann Arbor, Mich.* The value of bacteriologic cultures in the treatment of infected root canals and the inadequacy of x-ray methods to determine infection was discussed. The usual anaerobic methods for cultures have been too complicated to be used routinely, but the method of Brewer which consists of the simple addition of sodium thioglycollate to media, permits the use of anaerobic media for routine use. One hundred forty three cultures were taken of canals in various stages of treatment. Some had not previously been opened and others had already yielded 1 set of negative cultures. Ninety-two of the 143 cultures were negative in both media, while 24 were positive in both media. Ten were positive only in the aerobic medium and 12 were positive only in the anaerobic medium. This last variation is not uncommon when 2 tubes of the same medium are used and is the reason duplicate cultures are made. Four were negative in both media after 48 hours incubation but showed growth in the anaerobic medium after longer incubation. One was positive in the anaerobic medium and negative in the aerobic medium at the end of 48 hours. However the aerobic culture grew after longer incubation. In view of the small number of cultures which were positive only in the anaerobic medium, the difference between the 2 media does not seem significant. The

results of this preliminary study suggest that strict anaerobic conditions are not necessary for the routine cultivation of bacteria from infected root canals.

37. RELATIONSHIP OF SALIVARY SURFACE TENSION AND RATE OF FLOW TO DENTAL CARIES IN AN ADOLESCENT GROUP. *F. H. Cushman, D.M.D., J. W. Etherington, D.M.D., G. E. Thompson, D.M.D., Dental School, Harvard University, Boston, Mass.* These surface tension measurements were made on a Du Noy type apparatus, which was standardized between each group of readings. Collection of samples for testing was made 2–3 hours after meals. Mouths were first rinsed thoroughly, 4–5 cc. of unstimulated saliva were then collected in a test tube immersed in a vacuum bottle kept at 37.5°C. This was immediately transferred to a petri dish maintained at mouth temperature, and readings taken with a clean flamed loop. The reading of surface tension was taken as soon as sufficient saliva was available because of the tendency of readings to increase on long standing. In 15 minutes this increase observed averaged less than 1 dyme. Twenty-six patients were studied. In 10 having no new cavities, surface tension averaged 49.6 (range 45.5–52.2); 7 having 1–2 new cavities, S.T. averaged 51.8 (range 49.0–57.4); 9 having 4 or more cavities, S.T. averaged 54.6 (range 52.1–57.4). On this same group 10 minute samples of stimulated saliva were collected. These were taken on different days but under similar conditions. The 10 individuals with no new caries had an average stimulated salivary flow of 20.6 cc. (range 15–27); the 7 patients with 1–2 new cavities had an average flow of 16.6 cc. (range 15–21); those with 4 or more cavities averaged 10.1 cc. (range 5–15). The increase of caries was accompanied by increased salivary surface tension and reduced rate of flow.

38. DENTAL CARIES AMONGST TIBETANS AND BORDER ABORIGINES. *R. G. Agnew, B.A., M.Sc., L.D.S., D.D.S, College of Medicine and Dentistry, West China Union University, Chengtu, China.* Field studies involving 7 expeditions into western borderland of China and eastern Tibet (Kham) investigated conditions of life, adaptations and dietary and oral conditions amongst people of a civilization of richness but not complex in organization. Three geographic and dietary groups were encountered: 1. Upper Min Valley Group. Dietary—coarsely ground whole maize, vegetables scant, fruit negligible (only vitamin

C deficient, vitamin A marginal). Caries—36.5 per cent with 2.92 cavities per carious mouth. 2. Miao tribes (lowest altitude). Dietary—cornmeal partly replaced by polished rice, vegetables scant. Caries—52 per cent. 3. Eastern Tibetans (highest altitude). Dietary—dairy products, barley, tea (only vitamin C deficient). Caries—31.2 per cent with 2 cavities per carious mouth. Observations: 1. Refined foods unknown (except among Miao) yet caries incidence indicates this only one of multiple factors. 2. Caries not reduced in areas of fluorosis. 3. Oral hygiene and caries unrelated. 4. Pit, fissure and approximal caries predominant. 5. Attrition widespread but anterior crowding related to incisally inadequate function often encountered. 6. Psychic factors of worry and care absent. While resistance to caries is favored by adequate diet immunity is not result of any one univerally operative, dominant factor; seems resultant of protective balance of multiple forces readily disturbed in modern man.

39. Preliminary studies on caries immunity in Deaf Smith County area. *Edward Taylor, D.D.S., State Department of Health, Austin, Tex.* An extremely low caries incidence was found among native born, continuous resident, and, even to a high degree, foreign born residents around Hereford and Deaf Smith County, Texas. Teeth in this area typically show mild mottling, attrition and short crowns with very shallow grooves. Even in carious, new residents caries activity stops within a few months. Mirror and explorer examination of 289 continuous resident school children showed 1.23 DMF teeth per child; in whole group of 540 elementary school children DMF was 1.47, in 189 continuous residents 1.05, in 351 non-continuous residents 1.69. In Randall County (east) 129 children had 1.57 DMF; in Coryell County 113 had 1.69 average DMF teeth. In Deaf Smith County caries is directly proportional to mottling, in Coryell County reverse is true. Hereford flour is 6 times standard in P, lower in Ca; local milk yields 30 per cent more P; water has 2.2–2.7 ppm. fluorine, 45 ppm. Ca, pH 7.5–7.7; locally raised foods are higher in P than standards. The *L. acidophilus* count is directly proportional to the number of cavities. No single factor seems responsible for the caries immunity which is, at least partially, post-eruptively acquired. There seems to be an optimum fluorine concentration and high phosphorus

content in foods. *B. acidophilus* level is proportionate to caries. Further intensive studies are in progress.

40. THE CONTROL OF DENTAL CARIES BY ORAL HYGIENE PROCEDURES. *L. S. Fosdick, Ph.D. and D. Y. Burrill, A.B., D.D.S, School of Dentistry, Northwestern University, Chicago, Ill.* Twenty patients were selected on the basis of their susceptibility to caries. Each patient was given a complete mouth examination by clinical procedures in conjunction with radiographs. The results of this examination were recorded in such a manner that the exact location of each cavity or filling was included in a permanent record. Before the hygiene procedures were instituted each cavity was filled and several chemical tests for susceptibility were made. Each patient was +3 or +4 susceptibility at the start of the experiment. After the cavities were repaired and chemical susceptibility was known each patient was required to thoroughly cleanse his mouth immediately after the ingestion of food. The oral hygiene procedure was to forcibly rinse the mouth with a chlorothymol solution, chew a stick of chlorothymol impregnated paraffin for 10 minutes and to brush the teeth with a dentifrice and brush. This stringent oral hygiene procedure was continued for a period of 6 to 10 months during which time frequent examinations for chemical susceptibility were made. During this interval the susceptibility of each patient was materially reduced according to the chemical test, and clinically 4 of the 20 patients developed carious lesions although there were questionable areas in 3 of the patients.

41. EFFECT OF ORTHODONTIC TREATMENT ON CARIES SUSCEPTIBILITY. *D. Y. Burrill, A.B., D.D.S, School of Dentistry, Northwestern University, Chicago, Ill.* Determinations of caries susceptibility were made by chemical and bacteriological tests on 25 patients before the start and during the course of orthodontic treatment. Extremely susceptible patients become less susceptible during treatment. Patients of low susceptibility tended to become more susceptible. A third group of high average susceptibility was unpredictable, changes occurring in both directions. An explanation is suggested, that the increased use and supervision afforded by the orthodontist kept the bad cases cleaner, while the appliances afforded increased food traps and regions of stagnation in the naturally clean mouths. The data are not yet

complete as the patients are still under treatment and further determinations will be made during and after treatment.

42. PROGRESS REPORT ON A CONTINUOUS STUDY OF THE FLORA OF BACTERIAL PLAQUES FROM PROXIMAL SURFACES OF PREMOLAR TEETH BEFORE AND AFTER THE ONSET OF CLINICAL CARIES. *J. R. Blayney, S. F. Bradel, R. W. Harrison and Elizabeth Hemmens, Walter G. Zoller Memorial Dental Clinic, University of Chicago, Chicago, Ill.* This preliminary report presents the findings of a long term, parallel clinical, roentgenological and bacteriological study of smooth surface areas of premolar teeth in an effort to determine the changes in the bacteriological flora of the plaque which appear to be associated with the earliest stages of caries. After separation, irrigation, and drying, plaque material was removed from immediately beneath the contact and cultured aerobically and anaerobically in several bacteriological media. From 105 areas, 42 became carious while 63 remained negative. Of the 42 carious areas cultures from 6 were always negative for lactobacilli even after demonstration of caries; cultures from another 6 regions were all positive following the demonstration of caries; while cultures from 30 areas fluctuated from positive to negative. From 63 negative areas, cultures from 32 were all negative for lactobacilli; 3 areas were positive in more than 50 per cent of cultures; 24 areas were negative in more than 50 per cent of cultures; while 4 areas gave equal number of positive and negative cultures. Comparison of clinical and bacteriological findings showed 15 areas with positive cultures in advance of positive clinical findings; whereas in 14 areas, caries was demonstrated before a positive culture was obtained. Five areas were positive roentgenologically with all cultures negative; 1 area was positive roentgenologically and clinically with all cultures negative; 5 areas gave positive clinical and bacteriological findings simultaneously; while 2 areas gave positive roentgenological and bacteriological findings simultaneously. Complete bacteriological data will be given in another report.

43. ENAMEL PRODUCTION AND CALCIFICATION: NORMAL AND EXPERIMENTAL. *Friedrich Wassermann, M.D., Walter G. Zoller Memorial Dental Clinic and the Department of Anatomy, University of Chicago, Chicago, Ill.* In vitamin C deficient guinea pigs, enamel production is variously disturbed. Thereby the participation of the stratum cells

in the production of enamel becomes evident. The ameloblasts have functions in addition to sharing in production of enamel. The product of the ameloblasts and stratum cells is incomplete when injury to the odontoblasts results in poor dentin formation. The production of enamel globules and the building up of enamel matrix are 2 distinct processes. Maturation of enamel matrix coincides with the transformation of high ameloblasts into the low or reduced form. These short ameloblasts are not degenerating but have a special function, indispensable for maturation and not the transfer of calcium. It is shown that calcium is present in early enamel matrix and is continuously added until development is complete. It appears that the short ameloblasts are active in removal of organic material from the matrix. Continuous calcium intake and removal of organic matrix during maturation are essential to final crystallization of enamel.

44. VASCULARIZATION AND THE HISTOGENESIS OF HYPOPLASTIC ENAMEL. *S. W. Chase, Dept. of Anatomy, Western Reserve University, Cleveland, Ohio.* To test whether decreased vascularity of the papillae of the dental sac is a primary factor leading to abnormal retrogression of enamel organs which are forming hypoplastic enamel in rats' teeth, quantitative estimations of the ratio of blood volume to volume of component parts of the enamel organs were made by the paper-weighing method. Comparison of such estimates for enamel organs and blood vessels of 1. normal rats, 2. rats in which fluorosis had produced pronounced mottling of the enamel, and 3. rats in which fluorosis had produced marked gross hypoplastic defects, show that decreased vascularity usually precedes retrogressive changes in the papillae of the enamel organ and in the ameloblasts, but is not the sole causative factor in retrogression, which can also be caused by degenerative changes in the enamel organ not due to ischemia.

VIII. FOURTH SESSION: MORNING, MARCH 16; ABSTRACTS 45–58

45. THE EXISTENCE OF A PAROTID SALIVARY MUCINASE? *Norman S. Simmons, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Acid production studies on saliva using the differential volumeter (Fenn) technique, without added substrate shows that an insoluble substrate can be removed from the saliva, and has been shown to be the mucin. A plateau is reached early in the acid production in

saliva, filtered after standing during which time practically all the mucin flocculates, and on the addition of purified mucinate, the acid production is resumed. Unfiltered saliva shows a steady rate of acid production. This may be due to the liberation of the acid radicals of the prosthetic group or by fermentation of its carbohydrate components on enzymatic hydrolysis. Evidence has been found for the existence of an enzyme in saliva, probably in the parotid secretion, capable of eliciting a series of reactions with salivary mucin, which have been used as the criteria for the existence of other mucinases. In addition to the rapid depolymerization of the mucin as reflected in the viscosity and precipitability changes in dilute acetic acid, a secondary and slower hydrolysis of its prothestic group follows as evidenced by the liberation of reducing substances. The agent is non-dialyzable, thermolabile, and is inhibited by iodine and mercurial salts, but not by toluene, thymol, $CHCl_3$ or NaF in low concentrations.

46. STUDIES ON THE DISTRIBUTION OF RADIOACTIVE FLUORIDE IN THE BONES AND TEETH OF EXPERIMENTAL ANIMALS. *J. F. Volker, R. F. Sognnaes, and B. G. Bibby, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* The radioactive isotope of fluorine, $_9F^{18}$ with a half life of 112 minutes, was administered to 5 adult rats and 4 adult cats. After a suitable period, the experimental animals were sacrificed and radioactive fluoride content of various tissues determined with a Geiger-Müller counter. It was found that the blood fluoride falls rapidly and a corresponding rise in calcified tissue fluoride takes place. The radioactive fluoride concentration of the various skeletal components was approximately directly proportional to their proximity to the circulating blood. The greatest fluoride concentrate was found in the calcifying root portion of the rat incisor. No measurable fluoride could be detected in the incisal third of the rat incisor or the depulped canine crowns of the cat. The values for whole teeth are less than those for whole bone. In the cat group approximately 15 per cent of the total dose was excreted in the urine during the experimental period.

47. DISTRIBUTION OF INJECTED SODIUM IN THE TEETH AND BONES OF THE DOG AS SHOWN BY THE RADIOACTIVE ISOTOPE. *W. F. Koss and J. T. Ginn, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Radioactive sodium (Na^{24}) was injected

intravenously into 1 young and 4 adult dogs. The animals were sacrificed 12 hours following injection and the radioactive sodium content of various samples of teeth and bone was determined with the Geiger-Müller counter. There was considerable variation between dogs, in the uptake of radioactive sodium by their tissues, due perhaps to differences in their weight, age and rates of excretion. However, although the absolute amount varied from dog to dog, the ratio of Na^{24} uptake between the various tissues in individual dogs seems quite constant. The youngest dog showed by far the greatest uptake of Na^{24}. Two deciduous canines in this animal gave higher values than any of the permanent teeth, and all of the teeth gave values comparable to those of the bony supporting tissues. Experiments on 1 dog seem to indicate that the Na^{24} uptake by the teeth reached a constant level in from 6 to 9 hours following injection. (To be published in *J. D. Res.*).

48. ROENTGEN-RAY ABSORPTION STUDY OF HEREDITARY OPALESCENT DENTIN. *H. B. McCauley, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* It has been shown that normal dentin in its entirety shows a roentgen-ray absorption equivalent to 0.94 mm. of aluminum per mm. of thickness. In the present study, 15 slabs of hereditary opalescent dentin from teeth extracted from the same mouth, by roentgen-ray absorption analysis, showed an average absorption value equivalent to 0.75 mm. aluminum per unit thickness. This figure substantiates the finding that opalescent dentin contains a greater percentage of organic material than normal dentin, since the latter has a much higher interpolated value, a quantity which has been shown to be about 90 per cent dependent on the amount of calcium present.

49. LOCAL AND SYSTEMIC FACTORS IN EXPERIMENTAL RAT CARIES. *R. F. Sognnaes, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* A group of rats placed on a rachitogenic diet from weaning until they were 50 days old, were then given the coarse corn caries producing diet for 100 days. No marked difference was found in the incidence of molar caries between these animals and the normal rats fed the same diet. Removal of the molars in the upper jaw of rats fed a coarse corn diet, markedly reduced the incidence of caries in the lower molars. This would indicate that environmental factors

in the mouth play a major role in the initiation of the coarse corn molar lesions of the rat.

50. SPECTROGRAPHIC STUDIES OF POTASSIUM IN ENAMEL AND DENTIN. *L. T. Steadman, Harold C. Hodge, and Helen Wilson Horn, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* Despite several published chemical analyses which show that enamel and dentin contain about 0.2 per cent of potassium and despite several spectrographic studies which report the presence of potassium lines in arc spectra of these tissues, Lowater and Murray in 1937 conclude from a spectrographic study that normal human enamel and dentin do not contain potassium. In the current study, it has been found that both calcium and iron can mask the potassium lines and that, with suitable technical refinements, potassium lines can be demonstrated in normal human enamel and dentin. Enamel appears richer in potassium than is dentin. (Published in *J. Biol. Chem.*, **140**: 71, 1941.)

51. BACTERIAL COUNTS ON SALIVA. *B. G. Bibby, B.D.S., Ph.D., D.M.D. and Dorothy W. Maurer, Tufts College Dental School, Boston, Mass.* Comparisons of the number of organisms estimated by cultural methods and direct counting procedures confirm the findings of other investigators in showing that only a small percentage of the total bacterial population is revealed in plate counts. Because different counts were found in plates made from different dilutions of saliva it seemed possible that agglutination of organisms might be influencing the results. Comparisons of the occurrence of clumps of bacteria in hemocytometer counts, and colony counts made from fresh and standing saliva indicated that agglutination was taking place. Of the various methods used to reduce the spontaneous agglutination of salivary organisms the addition of 1 per cent of horse serum to standing saliva or saliva dilution tubes has been the most satisfactory. By following such a procedure plate counts averaging 16.8 per cent of the total flora have been obtained, a percentage 6 times greater than that reported by previous authors.

52. COMPARISONS OF SOME HYPODERMIC NEEDLES REGULARLY USED IN DENTISTRY. *F. A. Peyton, D.Sc., School of Dentistry, University of Michigan, Ann Arbor, Mich.* Tests have been made on 12 brands, new 25 gage, $1\frac{1}{2}$ to $1\frac{7}{8}$ inch, 4 each American Luer, cartridge and shimmel type needles, of which only 3 were known to be imported.

One brand was carbon steel, 1 nickel alloy, and the remainder designated as rustless or stainless steel. Stiffness tests were made on an Olsen stiffness tester (*J. A. D. A.*, **27:** 232, 1940). Eight needles were so similar in their stiffness characteristics that a choice could not be made between them on the basis of this property. The nickel needle was about ½ as rigid as the stainless steel needles. The carbon steel needle was approximately ½ times more rigid than the average stainless steel needles. Cold bend tests were made on an instrument similar in design to that described by Johnson for making cold bend tests on wire material (*Proc. A.S.T.M.*, **30:** 119, 1930). Five needles, 4 stainless steel and 1 nickel, gave an average of 7 to 9 bends of 90°. Two needles, one imported, gave an average of approximately 10 cold bends. Five needles developed less than 6½ bends; the carbon steel needle withstood less than 2 bends. A wide variation exists in the points of the needles available. Some are quite jagged and poorly finished; others are burnished and well designed to prevent unnecessary tissue damage. Worner has reported similar studies on hypodermic needles (*Aust. J. Dent.*, **44:** 205, 1940).

53. TIME REQUIRED TO CAST GOLD BY CENTRIFUGAL FORCE. *Raymond E. Myers, D.D.S., B.S., School of Dentistry, University of Louisville, Louisville, Ky.* Time required to cast gold by centrifugal force was measured by breaking an electrical circuit simultaneously with the start of rotation of the cross-bar of the machine and making the circuit again by contact of the molten gold with platinum wires imbedded in the mold. These break and make impulses were transferred through the writing point of an electromagnet to the blackened drum of a motor kymograph. The interval was measured by tracing the vibrations of an electrical tuning fork across the recorded impulses of the electromagnet and dividing the number of vibrations between the break and make impulses by the frequency of the fork. The measurements were accurate to $\frac{1}{128}$ or 0.008 second. The values obtained under varying conditions were compared with those previously reported (Myers and Pfeiffer, *J. A. D. A.* **27:** 530, April, 1940) in experiments with air pressure machines. (To be published in *J. A. D. A.*)

54. ON THE GROWTH PATTERN OF THE HUMAN HEAD FROM THE THIRD MONTH TO THE EIGHTH YEAR OF LIFE. *Allan G. Brodie, Graduate School, University of Illinois, Chicago, Ill.* Twenty-one white males

were serially x-rayed in the Broadbent-Bolton cephalometer from the 3rd month to the 8th year of life. Tracings of the films were made and the resulting figures were divided into brain case, nasal area, upper alveolar area and mandible. All linear and angular measurements were corrected. Composite figures derived from the means of all measurements at each of the 14 growth stages were constructed for each area. Superposing of composites revealed that the morphogenetic pattern was probably established by the 3rd month and thereafter did not change. The nasal floor, the occlusal plane of the teeth and the lower border of the mandible all maintain constant angular relations with the cranial base. The face as a whole travels downward and forward on a straight line. The several parts of the face maintain a constant proportionality with the nose invariably contributing 43 per cent. The sum of the increments of anterior face height is equalled by the growth at the mandibular condyle which exhibits a growth mechanism and potential similar to a long bone. The mandibular angle does not change as has been universally taught, and this bone bears the same angular relation to the cranium at 3 months as at 8 years, although the tongue protrudes between the gum pads and supports the lips. The teeth bear constant angular relations to the face.

55. EXPLANATION OF A FALLACIOUS FINDING IN DENTAL HISTOLOGY. *Balint Orban, M.D., D.D.S., Foundation for Dental Research of the Chicago College of Dental Surgery, Chicago, Ill.* In extracted perfectly normal teeth cell enclosures have been found in the dentin. At the same place the odontoblasts were missing. At first it could not be determined what these cells were and how they got into the dentinal tubuli. After repeated observation we were led to the belief that the pressure of the forceps during the extraction is responsible for these findings. This assumption was confirmed by experimentation. Teeth have been extracted, some having the forceps applied labiolingually and other mesiodistally. The cell enclosures always have been found corresponding to the injury on the tooth surface due to the pressure of the forceps. The cell enclosures were found not diametrically opposite the injury but corresponding to the course of the dentinal tubules. The cell enclosures were odontoblasts which have been pumped or sucked into the dentinal tubuli due to the pressure and injury caused by the branches of the forceps.

56. DISTRIBUTION OF PHOSPHATASE IN GINGIVAL TISSUE. *H. A. Zander, M.S., D.D.S., School of Dentistry, Northwestern University, Chicago, Ill.* The phosphatase containing cells of gingival tissue were made distinguishable by Gomori's histological method. Phosphatase was found in the endothelial cells of the capillary walls, and possibly in some connective tissue fibers. No phosphatase was found in the epithelium or in desquamated epithelial cells. These results are contrary to earlier findings of G. H. Smith, that phosphatase was found in desquamated epithelial cells. Smith thought to exclude salivary bacteria as sources of phosphatase by killing the bacteria with chloroform. The chloroform, however, extracted the enzymes from the bacteria and left them in solution in the saliva. Smith centrifuged the saliva to free it from epithelial cells, but in doing so he also freed it from bacteria. The bacteria of the mouth are the most likely source of the phosphatase which may be instrumental in the formation of salivary calculus. The localization of phosphatase in the subepithelial capillary walls may explain the formation of subgingival calculus, since the serumal exudate of gingival pockets where the epithelium is destroyed, would be expected to contain phosphatase.

57. STUDIES ON ENAMEL. I. THE YELLOW COLOR OF THE INCISOR TEETH OF THE ALBINO RAT. *Georg Stein, M.D. and Paul E. Boyle, D.M.D., Dental and Medical Schools, Harvard University, Boston, Mass.* The enamel of the incisor teeth of the albino rat is colored a deep orange yellow. The stain is present in the outer part of the enamel and first appears about midway from the formative to the incisal end of the tooth in a region where the full width of the enamel has been formed and where calcification has progressed to a stage where all or almost all the enamel disappears upon decalcification. The color may not develop in animals kept on vitamin A deficient or anemia-producing diets. Beginning approximately at the border between the proximal and middle thirds of the tooth, yellow granules have been observed in the ameloblasts and the cells of the stratum intermedium. The enamel cuticle is already formed in this region. At about the middle of the tooth the stain passes through the cuticle and is deposited in the outermost layer of the enamel, whereupon this layer becomes acid-resistant (5 per cent HNO_3). After decalcification of the stained part of the incisor, 2 membranes remain between the ameloblasts and the dentin, 1, an outer, primary cuticle about 1 micron

thick, 2, a yellow layer which retains the pattern of the enamel rods, about 8 microns thick. Surgical destruction of the enamel organ in the proximal third of the tooth resulted in spots of uncolored enamel, observed upon subsequent eruption of the affected tooth structure. The pigment is not a porphyrin or a lipochrome but appears to be a melanin.

58. CEPHALOMETRIC INVESTIGATION OF THE OPENING MOVEMENTS OF THE MANDIBLE. *John R. Thompson, D.D.S., M.S.D., M.S., School of Dentistry, University of Illinois, Chicago, Ill.* The controversy as to whether the suprahyoid muscles or the external pterygoids are the responsible agents in depressing the mandible, has long existed. A review of the literature reveals that most anatomical textbooks maintain that the suprahyoid muscles, because of their position of mechanical advanage, supply the motive power. This investigation consists of a study of the opening movement in normal individuals and in a number in which the influence of the external pterygoid muscles have been impaired or entirely eliminated (bilateral fracture of condyles, paralysis, bilateral and unilateral ankylosis and resections). In the normal opening the hyoid bone maintains a level well above that of the symphysis of the mandible and the suprahyoid muscles are not in a position of mechanical advantage to depress the mandible. In the abnormal cases where the external pterygoid cannot function, the hyoid bone is pulled downward below the level of the symphysis so that the suprahyoids are now in a position of mechanical advantage. The depression, however, is a pure hinge movement and it is limited in extent.

IX. FIFTH SESSION: AFTERNOON, MARCH 16; ABSTRACTS 59–71

59. RELATIONSHIP OF GASTRIC ACIDITY TO ALVEOLAR BONE RESORPTION. *Julius Brechner, D.D.S., M.S. in Dent. and W. D. Armstrong, Ph.D., M.D., Laboratory of Dental Research, University of Minnesota, Minn.* Absorption of calcium from the small intestine is facilitated by acidity of the intestinal contents consequent upon proper HCl production by the stomach. For this reason and because there is an apparent relationship of age distribution of senile osteoporosis, periodontoclasia and physiological achlorhydria, it seemed possible that some cases of alveolar bone resorption might be a result of inadequate

calcium absorption due to abnormally low HCl secretion The gastric juice stimulated by the alcohol test meal of 49 persons, divided into groups as indicated in the table, have been studied. The results of analysis for HCl are reported in degrees.

AGE	SEX	NUMBER OF CASES	FREE ACID RANGE	FREE ACID MEAN	TOTAL ACID RANGE	TOTAL ACID MEAN
			Control group			
21–42	M	(12)	4.70°–60.36°	37.57°	13.07°–76.82°	52.79°
16–35	F	(10)	7.33°–45.75°	25.96°	14.93°–81.05°	45.27°
16–42	M + F	(22)	4.70°–60.36°	31.76°	13.07°–81.05°	49.03°
			Alveolar resorption group			
21–50	M	(16)	0° –61.90°	16.89°	3.67°–79.76°	27.78°
19–51	F	(11)	1.91°–28.83°	10.63°	9.04°–38.80°	22.16°
19–51	M + F	(27)	0° –61.90°	13.76°	3.67°–79.76°	24.97°

The male controls (negative x-ray evidence of alvolar resorption) had respectively 122 and 90 per cent more free and total HCl than males exhibiting the condition. Corresponding figures for the females were 144 and 104 per cent and for all persons irrespective of sex, 131 and 96 per cent.

60. OSTEOGENESIS: VARIABILITY, BONE MORBIDITY AND SIGNIFICANCE IN CLINICAL DENTISTRY, *S. Rabkin, D.D.S., Cincinnati, Ohio.* Excluding interference during early childhood, structural formation of bone will proceed according to a predetermined morphologic pattern commencing with the first cell. Aside from physical variabilities and varied histogenetic cellular constituents, chemical consistency of bone depends upon organic and inorganic substances embodying basic properties for bone formation. Deviations from normal caused by infections, achondroplasia, rachitis, etc., ensuing during bone development may occur from infancy up to maturity. The morphogenesis of all bone structure is inherently characteristic of the individual (unless altered by extraneous causes) and prevails throughout skeletal frame, excepting digressions occurring in jaw bones. Distinctions in physical features between jaw bones and rest of the skeleton are in disparities in thickness and density of cortex and supporting spongiosa which is dissimilar to uniformity in long bones and that jaw bone does not receive the same soft tissue protection. Notwithstand-

ing the uniformity of the osteogenetic characteristics which prevail throughout individual entire frame, jaw bone is predestined to continuous insults and degenerative changes not encountered by any other part. Examination of skeletal material (dry and sectioned wet specimens) discloses a vast disparity in bone formation covering roots of teeth and in adjacent spongiosa. The abnormal variety of bone structure invariably leads to premature alterations and degenerative changes (osteoporosis, atrophy, osteolysis, osteoclasis) ordinarily associated with senility, resulting in necrosis of the alveolus. Further damage results from infection and debris admitted through loosely attached gingival tissue. To the clinician, study of osteogenesis in general and in particular, is very important. The evidence derived will serve as a most reliable guide to operator in treating alveolar disease, in extraction and curettement of necrosed bone, in preparation of jaws following extractions for artificial restorations, etc.

61. EFFECTS OF THE REMOVAL OF PULP AND HERTWIG'S SHEATH ON THE ERUPTION OF INCISORS IN THE ALBINO RAT. *Fred Herzberg, D.D.S., M.S. and Isaac Schour, D.D.S., Ph.D., Dental School, University of Illinois, Chicago, Ill.* The lower left incisors of 12 albino rats were subjected to pulp removal with the right lower incisor serving as a control. An opening was made with a small round bur on the labial aspect of the tooth near the gingival level and the pulpal walls were curetted thoroughly with broaches. Both lower incisors were notched near the free gingivae with a file to note the amounts of eruption. Both teeth erupted at identical rates. Hertwig's sheath was removed in the lower left incisors of 12 albino rats. The right side served as control. An extra-oral incision exposed the growing odontogenic base which was then excised. Both teeth were notched near the free gingivae. Appositional growth ceased in the lower left incisor but eruption proceeded at the same rate as in the control. Radiographic and histologic examination showed the path of eruption left by the tooth after it had erupted out of the socket. The pulp and Hertwig's sheath (odontogenic epithelium), and therefore the growth of dentin, increase in tooth length and pulpal constriction are not essential to tooth eruption. The growth of dentin and the eruption of the tooth are separable processes in tooth development.

62. HISTOLOGIC STUDY OF BONE HEALING FOLLOWING TOOTH EXTRACTION. *F. R. Christopher, D.D.S., and W. R. Schram, D.D.S., M.S.D., School of Dentistry, Northwestern University, Chicago, Ill.* Histologic studies of extraction wounds have been made almost entirely on dogs. In order to obtain human material for similar studies sections were cut from sockets in various conditions of healing. In early cases of delayed healing the labial plate of bone was cut from the socket by a specially constructed instrument. In normal healing and advanced abnormal healing, a muco-periosteal flap was raised exposing the bone to the apex of the socket. A lightening disc was used to cut through labial bone and socket content, and a section lifted out without disturbing the relationship of the bone and soft tissue of the socket. Microscopic preparations from this material were used to study normal healing, abnormal healing, and the repair that follows abnormal healing. These studies seem to show that: 1. The progress of healing in human tooth sockets parallels that reported in dogs, and proceeds at about half the rate. 2. The bone immediately surrounding the tooth socket dies if it is not properly protected by a blood clot. 3. The dead bone which remains in the area, as healing takes place, is gradually destroyed by osteoclastic action. 4. The process of repair is carried forward by the proliferation of connective tissue from the surrounding bone.

63. GRINDING METHOD FOR IN SITU EXAMINATION OF PIT AND FISSURE CARIES. *Grant Van Huysen, School of Dentistry, University of Louisville, Louisville, Ky.* The apparatus consists of a microtome, electric motor with chuck and stone, and a microscope. All 3 parts are firmly fastened to 1 surface. They are arranged so that the embedded tooth placed in the microtome holder will pass up and down over the grinding edge of the stone mounted on the motor shaft. The grinding wheel and embedded specimen are so adjusted that grinding is accomplished as the microtome carrier with specimen are in the lower half of their vertical movement. The microscope body tube with optical system is arranged horizontally in front of and above the revolving stone so that as the carrier and specimen come into the upper half of its vertical movement, the specimen may be viewed or photographed. This method permits tooth material to remain in its natural position for examination.

64. GROWTH OF ORAL LACTOBACILLI IN SALIVA. *Thomas J. Hill, D.D.S., and Albert H. Kniesner, B.S., D.D.S., School of Dentistry, Western Reserve University, Cleveland, Ohio.* Saliva was subjected to various treatments in order to determine which factors influence lactobacilli growth. Results were based chiefly on growth of lactobacilli inocula containing known numbers of bacteria in salivas. 1. Refrigeration (4°C) does not materially change the ability of saliva to support bacterial growth. 2. Centrifuged saliva shows no change. 3. Filtering mechanisms result in salivary media less suitable for bacterial growth. 4. Saliva collected from a caries-susceptible patient shows a decreased lactobacilli growth if boiled for 10 minutes. 5. Heating salivas at lower temperatures for longer periods of time gives similar results. Incubation of fresh "susceptible" saliva for 24 hours converts such saliva from an originally fertile medium to a poor medium for lactobacilli growth. 6. "Resistant" saliva collected from patients free from dental caries does not support acidophilus growth. With addition of a thoroughly washed, heat-killed strain of oral lactobacilli, staphylococci, Type I pneumococci, or hemolytic streptococci to such saliva, inoculated lactobacilli grow well. 7. Salivas with greater percentages of dextrose than a 2 per cent solution show no differences in growth. 8. With salivas which have been studied for 6 months, no correlation of caries susceptibility could be made with buffering index determinations. 9. On 4 test samples of saliva, the 2 resistant salivas showed a cocarboxylase content $2\frac{1}{2}$ times that of the 2 susceptible salivas.

65. THE RATE OF PUTREFACTION OF SALIVA IN RELATION TO PERIODENTOSIS. *David B. Law, B.S.D., D.D.S. and L. S. Fosdick, Ph.D., School of Dentistry, Northwestern University, Chicago, Ill.* The rate of putrefaction of saliva from periodontosis and normal cases was measured by means of the osmoscope and by Sorenson's titration. Saliva was gathered from normal and periodentosis individuals and was immediately incubated at body temperature. The pO value of the freshly collected saliva and at half hour intervals was measured and recorded. Final titrations were made on the same type of saliva immediately after secretion and after incubating at body temperature at the same intervals. It was found that the saliva from individuals with periodentosis had an initially higher pO value than did normal

patients and the rate of putrefaction as measured by the osmoscope was faster in the saliva from those individuals suffering from periodontosis. The degree of proteolysis as measured by the final titration indicated that proteolysis was greater in the individuals suffering from periodontosis than in normal cases. On the basis of these experiments it was concluded that putrefaction may be a factor in periodontosis.

66. LACTIC ACID FORMATION IN CARIOUS LESIONS. *O. E. Fancher, B.S. and L. S. Fosdick, Ph.D., Northwestern University, School of Dentistry, Chicago, Ill.* The lactic acid content of the material from carious lesions was determined before and after the ingestion of sugar. It was found that the lactic acid increased from 50 to 200 per cent within 10 minutes after the ingestion of the sugar. Calculations based upon the lactic acid content of the carious lesions and the pH of these lesions indicated a tremendous neutralizing effect inherent in the material. With a pH of 5 it was found that only 1 part out of 15 of the lactate remained as free lactic acid and at a pH of 6 only 1 part in 158 remained as free lactic acid. It was also calculated that if the change in pH from 5 to 6 was a result of decalcification of tooth structure .013 mg. of enamel would be dissolved by the average amount of lactic acid formed.

67. CLINICAL AND RADIOGRAPHIC STUDIES OF HEREDITARY OPALESCENT DENTIN. *W. E. Koch, Jr., D.D.S. and Hamilton B. G. Robinson, D.D.S., M.S., Washington University School of Dentistry, St. Louis, Mo.* Two children and their mother with hereditary opalescent dentin were examined clinically and radiographically. The mother had all teeth present restored with porcelain jacket and full cast crowns. The roots appeared short, practically all root canals were obliterated and the supporting and alveolar bone appeared normal. The 14 year old girl had short roots, the crowns on recently erupted teeth were normal in contour, all pulp chambers and most pulp canals were obliterated, and the supporting and alveolar bone appeared normal. She had a slight distocclusion on the right with approximately normal arch form. The 5 year old boy showed marked attrition of his deciduous teeth, normal root resorption and absence of pulp chambers. The erupted permanent mandibular incisors were of normal size and contour and as yet showed no attrition. The unerupted 2nd mandibular incisors showed no pulp chambers, radio-

graphically. A 17 year old sister and an 8 year old brother had normal teeth. Effected teeth were typically opalescent, markedly worn but not with typical caries, had enamel which chipped readily. The only exceptions were newly erupted teeth with intact, opalescent enamel and normal size crowns. The color, lack of resistance to attrition and reduction in pulp cavity are apparently developmental; attrition and chipping are post-eruptive.

68. HEMANGIO-ENDOTHELIOMA OF THE ORAL TISSUES. *Hannah E. Silberstein, B.A., Indiana University Dental School, Indianapolis, Ind.* Hemangio-endothelioma offers a convenient classification for a certain relatively benign neoplasm that is a problem in diagnosis. Several angioma and endothelioma exhibit some common features of this tumor and should be differentiated from it. The term hemangio-endothelioma has been applied to that group showing slow growth, moderate infiltrative characteristics and dense proliferation of endothelial cells intimately related to the connective tissue stroma. The few cases reported in the literature and the 3 reviewed in this report seem to have close association with history of trauma. 1. An 8-year old boy developed a small tumor at site of injury to his upper lip. Microscopic: marked capillary proliferation and densely packed endothelial cells with typical clear cytoplasm and vesicular oval nuclei. 2. A slow-growing tumor occurred in the palate of a 15-year old girl with no known history of trauma. Microscopic: dense endothelial cell masses and small blood spaces, the entire area surrounded by a solid vascular fibrous wall. 3. A 72-year old woman developed a primary hemangio-endothelioma of the hard palate. When first seen it was of 8 years duration, with a history of constant trauma due to a loose-fitting upper denture. The first biopsy resembled a cellular hemangioma. Three years later biopsy showed great increase in atypical cells quite characteristic of an epithelial tumor. Definite diagnosis of hemangio-endothelioma made after metastasis to the cervical lymph nodes. Operated metastatic lesion showed solid cords of endothelial-type cells, with many mitotic figures, intimately related to connective tissue stroma; several open blood spaces and almost complete obliteration of parenchymatous glandular elements. Post-operative prognosis in each of the cases was favorable.

69. THE ORAL MANIFESTATIONS OF VITAMIN B COMPLEX DEFICIENCIES. *Arvin W. Mann, D.D.S., Tom D. Spies, M.D., and Monette Springer, R.N., University of Cincinnati and University of Texas.* Pellagra, beriberi, and riboflavin deficiency are diseases caused by a fractional deficiency of vitamin B complex factors. Pellagra symptoms can be divided into prodromal, acute, and advanced. Prodromal symptoms consist of burning sensations in the tongue and mucous membranes of mouth. Swelling of the tongue causes teeth indentations along lateral borders. A few red, hypertrophied papillae are found at the tip. These symptoms are more severe in acute pellagra. Many red, hypertrophied papillae appear on tip and lateral borders of tongue. The tongue and oral mucosa are very tender. Oral mucous membranes are fiery red and very vascular. As pellagra enters the advanced stage, the interdental papillae are attacked. Massive periodontal breakdown is fostered. Papillae disappear from the tongue leaving a smooth, slick appearance. Vincents' infection is present in direct proportion to the severity of the symptoms of pellagra, and disappears when medication dissipates the patient's pellagra symptoms. Riboflavin deficiency cheilosis appears at the corners of the mouth. An angry, red, triangular lesion spreads laterally to produce a wet, macerated, yellow patch. In the advanced stage, this patch disappears leaving the skin pigmented and smooth. Patients deficient in B_1 show a marked sensitivity of the oral tissues. Caries seems to be inhibited, and periodontoclasia increased in the group of riboflavin deficiency and pellagra patients studied.

70. PROGRESS OF GINGIVITIS INTO THE SUPPORTING TOOTH STRUCTURES. *Joseph P. Weinmann, M.D., Foundation for Dental Research, Chicago College of Dental Surgery, Chicago, Ill.* Histological investigations were made to ascertain where and how inflammation of the gingivae proceeds into the underlying tissue. A review of the literature revealed that opinions of various investigators on this question are varied. The study led to the following findings: Inflammation of the gingiva causes resorption of the alveolar crest on the periosteal side. Simultaneously the adjacent bone marrow spaces show transformation of the fatty marrow into an edematous connective tissue. The inflammatory reaction follows the course of the blood vessels

into the bone marrow spaces and along the periosteal side of the alveolar bone. The periodontal membrane is in all cases practically free from inflammatory cells. Regardless of the degree of gingivitis, inflammatory reactions in the periodontal membrane could be observed only in rare instances. In these cases the inflammation also followed the course of the blood vessels and probably passed through the bone marrow spaces into the periodontal membrane rather than coming directly from the gingiva. (Published in *J. Periodont.* **12:** 71, 1941).

71. PRIMARY CENTERS OF LOBULAR DEVELOPMENT AND CALCIFICATION IN THE TOOTH. *James Nuckolls, D.D.S., University of California School of Dentistry, San Francisco, Cal.* Tooth germs from unerupted molars of 1 day old rats were cultivated *in vitro* and a technique for implantation of tooth germ elements in rat brains was developed. Young material, undecalcified and cut at 10 microns, was specially stained for calcium. It was observed that: 1. Odontoblasts, once determined, form dentin. If the enamel epithelium is degenerated this dentin is irregular, but if this epithelium maintained intact the morphology of the tooth is reproduced grossly. 2. The tooth organizes a bony crypt for itself. The establishment of this crypt is in some manner related to the external enamel epithelium. This epithelium apparently is active in tooth eruption. 3. Calcium is laid down circumferentially about a pre-enamel rod derived from the ameloblast. The central core calcifies less densely a little later. 4. Strongly basophilic processes, believed to kerato-hyalin, extend from the junction of Tomes processes and ameloblasts, between the rods. Calcification of the kerato-hyalin matrix occurs after rod calcification by deposition of coarser, scattered, less dense granules.

X. SIXTH SESSION: EVENING, MARCH 16; ABSTRACTS 72–76

72. THE MEDICAL AVOCATIONS OF A PATHOLOGIST. *Robert A. Moore, M.D., Ph.D., Schools of Medicine and Dentistry, Washington University, St. Louis, Mo.* The influence of disease in social, political and economic history is far reaching. Anomalies, hereditary diseases, infections and dietary deficiences have all left their indelible marks. Disease has led to conquest, defeated armies and changed the political and economic systems of nations. Plagues have swept across large

areas at crucial times to effect the course of world events. The careers of statesmen, artists, writers and other leaders have been molded, interrupted or terminated by disease. Pathology and medical aid have been called on to decide apparently small events that have prevented major catastrophes.

73. ADDRESS OF RETIRING PRESIDENT. *Wilmer Souder, Ph.D., National Bureau of Standards, Washington, D. C.* (pages 217–220)

74. DENTAL SCIENCE AND DENTAL ART GRANT-IN-AID. *Hamilton B. G. Robinson, D.D.S., M.S., Washington University School of Dentistry, St. Louis, Mo.* The International Association for Dental Research, upon recommendation of its Committee on Grants, is authorized to award sums to individuals to aid research. The first series of awards are known as the *Dental Science and Dental Art Grants in Aid* and are available through the generosity of the editor, Dr. Samuel Gordon, and his collaborators to the book *Dental Science and Dental Art*. Awards are made only to assist in completion of work in progress or in publication of results of research and the recipient may not be more than 30 years of age. This year Dr. H. A. Zander, who is working at Northwestern University, is awarded the first grant to assist in purchase of materials and equipment to be used in investigation of the penetration of silver nitrate into dentin.

75. INTRODUCTION OF PRESIDENT-ELECT. *Frederick B. Noyes, A.B., D.D.S., Sc.D., School of Dentistry, University of Illinois, Chicago, Ill.* (pages 220–221)

76. INAUGURAL ADDRESS. *Isaac Schour, D.D.S., Ph.D., School of Dentistry, University of Illinois, Chicago, Ill.* (pages 221–230)

XI. PAPERS READ BY TITLE: ABSTRACTS 77–110

77. PROTECTIVE ACTION OF ENAMEL AND CEMENTUM CUTICLE. *B. G. Bibby, B.D.S., Ph.D., D.M.D. and Irving Glickman, B.S., D.M.D., Tufts College Dental School, Boston, Mass.* Incidental to histological investigation of periodontoclasia, studies were made of the enamel cuticle and the cuticle covering the cementum in areas adjacent to microscopic lesions of gingival "caries." It was found that while caries-like destruction of the cementum progressed apically and pulpally contiguous enamel surfaces were not involved. The destructive process was apparently inhibited by the presence of an enamel

cuticle, even although lateral spread of the "caries" into the dentin sometimes undermined the enamel. Where cementum was covered by an intact cuticle there was no destruction. However, because destroyed cementum was found while adjacent enamel remained intact, it seems that the protective action of the cementum cuticle is less effective than that of the enamel. Brownish hyaline zones conforming with the periphery of dentin and cementum destruction often extended for varying depths into these tissues. This change in structure was interpreted as a non-progressive transitional stage in the proteolytic destruction of tooth substance and adventitious deposits.

78. CONCERNING THE "VITALITY" OF THE CALCIFIED DENTAL TISSUES. IV. VITAL STAINING OF HUMAN DENTAL ENAMEL. *Charles F. Bodecker, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* A previous paper has shown the gross distribution of dyes by means of vital staining in the dentin and enamel of dogs monkeys and Man. Since then more teeth have been treated by W. Lefkowitz making a total of 183 observations. The present paper identifies the minute enamel structures permeated by dyes as tufts, spindles, lamellae, rod sheaths and cement substance. "Old" teeth and those showing attrition are far less permeable than young. The incorrect conception that the physical condition of teeth remains the same, whatever their age or degree of attrition, may be responsible for some erroneous generalizations concerning possible physiological activity in the calcified dental tissues. (To be published in *J. D. Res.*)

79. HISTOLOGIC STUDY OF DESQUAMATIVE GINGIVITIS. *Lester R. Cahn, D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* Desquamative gingivitis is a baffling condition characterized clinically by the disappearance, and at times the exfoliation of the covering epithelium. In the author's experience the lesion appeared in females between the ages of 25 and 55. Histologic studies were made from biopsy specimens from 2 patients. *Case 1:* The epithelium appeared fragmented and the tissue assumed a papilliform pattern. Superficial cells were being cast off continually. The stroma was slightly edematous. Deep in the tissue were fungi of the nocardial group. *Case 2:* The primary reaction in this instance was in the stroma. Edema raised the epithelium from stroma forming

small bullous-like lesions. The increased sub-epithelial edema compressed and atrophied the epithelium. The bulla contained inflammatory cells. With increase in fluid overlying epithelium became reduced to a few layers. When sub-epithelial edema increased in volume bullae would break leaving a raw bleeding surface. This covered over in time with a thin friable epithelium. A pure growth of *Staphylococcus aureus* was obtained from culture of aspirated contents of one of the bullae. Coccal forms were found deep in tissue and fungi about the surface. The pathologic processes in both cases were different. The microscopical examination gave no clue as to their origin, with the exception that it might point to either bacteria or fungi as a possible etiologic factor.

80. MITOSIS IN THE DEVELOPING HUMAN TOOTH GERM. *Moses Diamond and Edmund Applebaum, School of Dental and Oral Surgery, Columbia University, New York, N. Y.* In connection with a study of growth and development of the human tooth, an attempt was made to determine the stages in development of the enamel organ and the particular regional areas where proliferation or cell division occurs. With the aid of a green filter, mitotic figures were readily demonstrable in the dental lamina and outer enamel epithelium, as well as in the ameloblast prior to its being differentiated to produce enamel. Mitotic figures were also noted in the mesenchyme. The findings thus far support the idea that proliferation or cell division does not occur during the differentiation stage of the ameloblast.

81. STUDY OF THE ABRASIVENESS OF DENTIFRICE INGREDIENTS. *Sidney Epstein, D.D.S. and M. L. Tainter, M.D., College of Physicians and Surgeons, San Francisco, Cal.* A method has been developed for measuring abrasiveness of dentifrices with sensitive dial micrometer gauge measuring loss of tooth substance brushed under constant conditions in presence of dentifrice. Series of teeth are successively exposed to abrasive action of dentifrice and standard calcium carbonate control. Abrasiveness figure is related to that of the standard powder not affected by inherent variability of hardness of teeth used for test. Comparison of amount of abrasion produced by recently introduced synthetic bristles shows that they cause no more abrasion than best grades of natural bristles, but that they withstand much more wear. Brushing with moist brush in absence of abrasive material leads to

very little wear on teeth under conditions of testing. Thickness of slurry powder used produced only very slight change in amount of abrasion. When silica is added to control calcium carbonate, it has increased abrasion in concentrations as low as 0.078 per cent, indicating sensitivity of method. Amount of abrasion produced is modified by size of particles of dentifrice, coarser particles abrading more than finer. Different materials of similar particle sizes produce quite different degrees of abrasion, indicating importance of hardness and chemical structure of various agents. Comparison with glass slide technique shows present methods will detect differences in abrasive power too small to be demonstrated by former method. Studies on possible modifications of glass slide technique to improve its sensitivity, and on desirability of using metals rather than teeth are in progress. A survey of commercially available dentifrices is partially completed.

82. HISTOLOGICAL ANALYSIS OF EPITHELIAL CHANGES IN POCKET FORMATION. *Irving Glickman, B.S., D.M.D., Tufts College Dental School, Boston, Mass.* In a histological study of sections from 10 human jaws presenting different degrees of periodontoclasia and including periodontal tissues in relation to 41 teeth, (31 studied in serial section) the following observations are made concerning epithelium of the pockets: a. The most obvious change is proliferation and extension of stratum germinativum and stratum granulosum of the epithelium of the lateral wall of the pocket to form "pegs" and "buds" in underlying connective tissue. Associated with infiltration by inflammatory exudate from underlying connective tissue, epithelium in this zone presents varying degrees of necrobiosis and ulceration. b. It is felt that such epithelial changes are secondary to inflammation in underlying connective tissue and are not the mechanisms responsible for apical extension of the pocket. Such extension results from proliferation of the germinal layer of epithelium at the base of the pocket with formation of pseudopod-like projections along cementum. This opinion is supported by the fact that regardless of depth of pocket or extent of proliferative and degenerative involvement of epithelium of the lateral wall, epithelium at base of the pocket is intact and its continuity with cementum is not disturbed. In addition, extensive pockets are found presenting negligible changes in lateral epithelial

wall as contrasted with comparatively shallow pockets in which epithelium in this region is markedly involved.

83. SALIVA AND ENAMEL DECALCIFICATION. VI. PREDISPOSING FACTORS. *J. T. Gore, D.D.S., Philadelphia, Pa.* Discussion of predisposing factors in caries is largely limited to the source of H-ions. An hypothesis is presented that susceptibility to caries is largely dependent upon amount of insulin secreted, which is found in considerable quantities in the salivary glands. Erythrodextrin or glycogen have been reported found in saliva by Kirk and Michaels. Iodine tests on mandibular saliva gave satisfactory tests for erythrodextrin or glycogen. Failure to isolate glycogen from the secreted saliva may be due to rapid hydrolysis of the glycogen in mucin by the amylolytic enzymes, both secreted in the same glands. Diastatic tests with c.p. glycogen, using the author's saliva, showed the presence of glycogenase. After destroying all proteins and reducing sugars by boiling several hours in 30 per cent KOH, a carbohydrate remained in the saliva, which responded to the iodine test for erythrodextrin and, upon hydrolysis, gave a positive reaction for reducing sugar. (Published in *J. D. Res.* **20**: 107, 1941)

84. SALIVARY AMMONIA. *Carl J. Grove, Ph.G., D.D.S., and Carl T. Grove, D.D.S., St. Paul, Minn.* Bunting, Jay and others have found that lactobacillus, under the protection of the mucin plaque, forms acid of sufficiently low pH to break down enamel, and Belding and Belding and others have contended that acid producing streptococci are the responsible agents. It is generally agreed that there is an immunizing factor or factors in saliva of immune individuals that prevents formation of mucin plaques and inhibits growth of acidogenic organisms. In 1934 we presented work indicating that the ammonia of saliva is an inhibiting agent. Where caries is rampant, the ammonia content of saliva is very low, and where caries is mild or absent, it is high. The Folin-Bell-Permutite procedure was employed for ammonia nitrogen determinations. Our further studies have proven that ammonia in solution is a solvent of salivary mucous and mucous plaques and obviously an inhibitant of growth of lactobacillus. Ten cc. of a 0.1 per cent solution of ammonia will dissolve 300 mgm. of dried salivary mucin. Criticism has been made by White and Bunting and Youngburg of the method we employed. They contend

that an aeration procedure for determination of ammonia nitrogen is preferable and more accurate. Further research has indicated that their basis for criticism is not well founded. The Folin-Bell Permutite method calculates only non-protein nitrogen (ammonia) while the aeration method calculates nitrogeneous bases other than ammonia.

85. EFFECTS OF THYROXINE ON RATE OF ERUPTION AND DENTIN APPOSITION. *Fred Herzberg, M.S., D.D.S. and Isaac Schour, D.D.S., Ph.D., Dental School, University of Illinois, Chicago, Ill.* Sixty rats from birth to 35 days of age were given multiple injections of from .05 to .20 cc. of thyroxine and of .05 to .50 cc. alizarine Red S. Litter mates that were untreated (7) or injected with alizarine red S alone (12) were used as controls. The eruption of incisor into oral cavity was earlier in thyroxine-treated animals (3 days) than normal (8 to 10 days). This confirms the findings of Hoskins (*Proc. Soc. Exp. Biol. and Med.* **25:** 55, 1927) and Karnofsky and Cronkite (*Proc. Soc. Exp. Biol. and Med.* **40**: 568, 1939). The rate of eruption was accelerated as follows:

Weekly Rate of Eruption of Lower Incisors

	14–21 days	21–28 days
Normal	1.6 mm.	3.2 mm.
Thyroxine Treated	3.4 mm. (+1.8)	5.4 mm. (+2.2)

Roentgenograms and ground sections showed thinner labial and lingual dentin walls, wider pulp and greater tooth width than in controls. The rate of dentin apposition was normal. Calcification was normal except for non-specific calcio-traumatic lines. The skulls measured by method of Spence (*Angle Orth.* **10:** 127, 1940) were smaller than normal, but relative proportions were unchanged. The first molars erupted sooner in thyroxine-treated animals (at 14 days of age) than in normal (19 days).

86. HISTOLOGIC EFFECTS ON RAT TEETH BY FLUORINE ADMINISTERED IN DRY AND MOIST DIETS. *Murray M. Hoffman, B.S., D.D.S., M.S., Cecilia Schuck, Ph.D., and William J. Furuta, A.B., M.S., University of Illinois and Purdue University.* Thirty-three albino rats weaned at 21–24 days of age and placed on fluorine-containing diets in water, milk and dry food. Pigment, gross and histologic changes in incisors and molars showed that animals receiving fluorine in water (0.05 per cent NaF) were most severely affected; in milk next, and in dry

diet the least. Histologic changes in all experimental groups were as follows: 1. Degeneration of ameloblasts with enamel hypoplasia and cystic formations; 2. Incremental lines in enamel and dentin accentuated; rate of apposition remains at normal—16 microns/24 hrs.; 3. Rachitic-like changes in incisor and molar teeth—interglobular dentin; excessive osteoid in alveolar bone; 4. Retarded eruption of molars; 5. Persistence of organic enamel matrix in incisors and third molars—possibly associated with poor mineralization. Findings indicate that process of crystallization of mineral salts in enamel is en masse and probably occurs at the cessation of functional morphological and chemical differentiation of the organic matrix. Findings also suggest disturbances in the physiologic economy of calcium-phosphorus metabolism in presence of fluorine despite adequate mineral intake.

87. SOME OBSERVATIONS ON THE CONSTITUTIONAL FACTOR IN DENTAL CARIES. *V. O. Hurme, D.M.D., Tufts College Dental School, Boston, Mass.* An attempt has been made to determine whether a constitutional factor operates in production of dental caries. A dual approach to the problem has been employed: 1. the study of the individual as an isolated unit and 2. the study of the individual as a component of a group. The records of carefully conducted dental examinations, supplemented by data on stature, physical type, and racial stock of parents or grandparents, of 200 unselected, American born, white young male adults have been partially analyzed. The findings suggest a positive correlation between the number of damaged teeth and the following factors: 1. standing height; coefficient of correlation +0.28; standard error 0.07; 2. body build; 3. racial derivation; 4. miscegenation. The age range of the group studied is 19.5 to 29.5 years. Since the coefficient of correlation between damaged teeth and age in this group is very low, or +0.04, a relatively early manifestation of the constitutional character of an individual, insofar as his teeth are concerned, is suggested. The desirability of considering the genetic factor in all studies involving human material is stressed.

88. EXPERIMENTAL AND CLINICAL STUDY OF PULP AMPUTATION. *E. Frank Inskipp, D.D.S., and J. E. Markee, Ph.D., College of Physicians and Surgeons, and Stanford University, Calif.* Methods are seriously needed for preserving vital teeth when pulps have been

infected. If these teeth could be sterilized a functioning member greatly superior to any artificial tooth could be secured. The possibility of sterilizing infected pulps and promoting the development of secondary tissue to keep the tooth functioning and free of infection has been studied. In 7 monkeys, pulp chambers have been filled with Triopaste (Gysi), and tissues examined histologically 13 to 16 months later. In 6 of 7 teeth osteoid tissue or cementum formed in the canals or around the apices, demonstrating that Triopaste promotes development of secondary changes when applied in this area. Fillings of Triopaste were inserted in infected pulp chambers of 118 patients, in whom 40 were restudied 1 year later, by clinical and roentgenological methods. Of the 40 patients who can be used, 27 showed no evidence of further infectious changes around involved tooth, 3 constituted definite failures, the remaining 10 were doubtful as to their interpretation, because of technical failures in the original treatment or because of equivocal roentgenological findings. These observations demonstrate that it is possible to sterilize infected pulps and get physiological repair in a considerable proportion of patients. Since more than half of such teeth have been saved, such treatment would seem to merit very careful consideration, in selected cases, before extraction.

89. CAUSES FOR LOSS OF PERMANENT TEETH. *George W. James and Virgil D. Cheyne, B.A., D.D.S., Ph.D., Indiana University School of Dentistry, University of Indiana, Indianapolis, Ind.* The permanent tooth extraction incidence in 2000 patients (10–70 years) who presented themselves at the School of Dentistry the first part of the academic year, 1940–41 was studied. 459 patients actually experienced extraction of 1242 teeth. An attempt was made to differentiate those teeth lost because of caries and because of periodontoclasia. Some of the percentages overlapped because some teeth were removed for more than one reason. The carious tooth classification included those with large cavities or cases with only carious root fragments remaining (743 teeth [60 per cent]). Of 34 per cent radiographed prior to extraction 13 revealed definite pulpal involvement, while 12 showed apical involvement. A total of 422 teeth (34 per cent) were extracted because of periodontoclasia: 96 per cent with unquestionable loss of investing tissue; 2 per cent an additional generalized periodontitis. At time of extraction it was planned to replace

13 per cent with full dentures and 8 per cent with partial dentures. Nearly 1 per cent of the teeth were removed to correct malocclusion, 1 per cent for esthetic purposes, 3 per cent because of impaction, about 1 per cent under advice from the physician for general health reasons. A miscellaneous classification included 2 teeth extracted because they were supernumerary, 7 root tips left from previous extractions performed elsewhere. Gingival recession in combination with erosion caused a loss of 5 teeth; abrasion plus excessive erosion the loss of approximately 24 teeth. Arrangement of extraction groups according to decade showed caries uniformly the outstanding cause for tooth loss. The average age at which greatest number of teeth were removed because of periodontoclasia was 45 years while for caries it was 32.5 years. 30 per cent of all teeth removed were diagnosed radiographically.

90. REMOVAL OF BLOCK SECTIONS OF TEETH AND INVESTING STRUCTURES AT INTERVALS FOLLOWING SURGICAL OPERATION. *Harry Kaplan, D.D.S., Lt. Comdr., D.C., USNR and James B. Mann, D.D.S., M.D., Lt. Col. D.C., U. S. A., Washington, D. C.* The purpose of this study is to investigate the healing stages of epithelium, connective tissue, and bone, with special attention to the attachment of the healed investing tissues to the tooth. A well nourished male patient, laborer, age 45, with moderate to advanced periodontosis as observed clinically and by x-ray, was selected for the surgical elimination of the disease. The mandibular premolars, canines and incisors were operated by the Crane-Kaplan technique. Blocks composed of a tooth or teeth and the investing structures were removed at intervals. The first block, left 2nd premolar, was removed 2 days following operation. The second block, right 2nd premolar was removed 4 days after operation. The third block, right canine and second incisor, including the interproximal tissues, was removed 6 days after operation. The fourth block, left canine and second incisor was removed 16 days after operation. The fifth block, first incisors, was removed 21 days after operation. All blocks showed the usual clinical stages of healing without complication. After removal all blocks were placed in 10 per cent formalin solution for fixation and sent to the Registry of Dental and Oral Pathology, Army Medical Museum, Washington, D. C., for histological examination.

91. PATHOGENESIS OF COARSE CORN RAT CARIES. *B. Kearney, R. F. Sognnaes and B. G. Bibby, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* In order to study the sequence and pathology of experimental rat caries, the coarse corn caries producing diet was fed to a group of rats for over 100 days, groups of the animals being sacrificed at 2 week intervals. The teeth were first examined under the binocular microscope and subsequently prepared for histological examination in decalcified and ground sections. Cusp fractures were the dominant findings during the first weeks on this diet. Grossly the typical cavity formation did not occur before the rats had been 12 weeks on the diet. Histological study suggests that the enamel fractures follow a slight undermining of the supporting dentin. Lesions typical of fissure caries were relatively late and rare in occurence.

92. IMPROVEMENTS IN HISTOLOGIC TECHNIC FOR TEETH AND JAWS. *E. Kotanyi, Texas Dental College, Houston, Tex.* Studies have been made in an effort to improve such phases of histologic technic as decalcification, considered to need too much time; methods of testing decalcification, which seemed too inexact and injurious to tissue; and the concentration and other factors in celloidin infiltration. For decalcification 5 per cent nitric acid (sp. gr. 1.40, 7.5 cc. HNO_3 to 100 cc. H_2O) is used. Since agitation of the acid accelerated decalcification, compressed air was introduced into the bottom of the acid through a glass tube where it escaped through small holes in a rubber tube. The specimens were hung from the top of the jar by rubber bands so that they swayed midway in the jar. Puncturing to test for decalcification injured the tissue and was an inexact subjective method. X-rays were used to determine completion of decalcification and demonstrated that teeth of the same size needed less time with the new method than with the old. Contrary to some advice, it is necessary to leave specimens longer in thin celloidin than in thick. Specimens should be left in $2\frac{1}{2}$ per cent longer than in 5, and in 10 per cent longer than in 20. The low, damp climate caused rusting of the delicate knife edge and oiled paper around the edge was of little value. Suspending the knife in oil was effective. Paper wrapped around the mounting blocks to hold specimens during embedding stuck to the blocks but thin aluminum foil (.002–.003 in. thick) was found quite satisfactory.

93. EFFECT OF SALIVA ON CAPILLARY PERMEABILITY. *B. Levy, B.A., and J. L. T. Appleton, D.D.S., D.Sc., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* To demonstrate increase in capillary permeability a particulate dye is injected intravenously. The dye infiltrates the tissue surrounding capillaries of increased permeability to show through the skin. Previously depilatorized skin (of rabbit's abdomen) was intradermally injected with 0.2 cc. of stimulated whole human saliva and immediately followed by intravenous injection of 7 cc. of 1 per cent trypan blue. Within 5 minutes a blue blotch was noted at the site of saliva injection. To isolate the responsible factor salivary fractions were used. Centrifuged, filtered, dialyzed, heated (80°C. 5 min., 100°C. 5 min.), ether extracted and electrophorized (negative pole greater) salivas increased and dialysate, distillate and residue of saliva failed to increase permeability. Physiologic saline, distilled water, Ringer's solution, 0.1 per cent protein (horse serum) in distilled water were used as controls and gave negative results. A turpentine control increased permeability. It is concluded that the responsible factor is not living bacteria, salts, proteolytic enzymes, proteins, ether-soluble fraction, pH or hypotonicity. It is in the fraction which tends to concentrate around the negative pole.

94. HISTOLOGIC STUDIES OF BLOCK SECTIONS OF TEETH AND INVESTING STRUCTURES REMOVED AT INTERVALS FOLLOWING SURGICAL OPERATION. *James B. Mann, D.D.S., M.D., Lt. Col. D.C., U. S. A. and Harry Kaplan, D.D.S., and Lt. Comdr. D.C., USNR, Washington, D. C.* Blocks consisting of teeth and a portion of the investing structures, fixed in formalin, were decalcified and histological sections made using paraffin technique. Sections of a block removed 2 days after operation show superficial hyalinized layer of fibrin with a few cellular blood elements enmeshed in the upper portion. Deeper and covering the crest of the alveolar process is a layer of fibrous tissue, apparently not disturbed in the operative procedure. There is evidence of a mild chronic inflammatory process. The gingival epithelium stops abruptly at the point of incision. Sections of a block removed 4 days after operation show a rather thin layer of epithelium extending over a narrow zone of hyalinized fibrin which overlies a narrow strip of connective tissue above the alveolar crest. This epithelium is apparently a new growth and has no rete peg formation such as seen in

the undisturbed adjoining epithelium. There is a space next to the tooth where the organizing tissue is not covered by epithelium. Sections from a block removed 6 days after operation show a rather thin layer of new epithelium extending over the entire healing surface and to the cementum. There is evidence of much fibroblastic activity in the underlying tissue, with quite a few plasma cells and occasional round cells. Osteogenesis is evidenced around the alveolar crest which seems undisturbed at this point. Sections of a block removed 16 days after operation show that the epithelium covering the newly organized tissue has taken on the same form and appearance as the remaining gingival epithelium. The newly formed gingival crevice is very shallow and the underlying connective tissue stroma is becoming well organized by fibroblastic activity. Sections of a block removed 21 days after operation show a thin cornified layer over the epithelium outside the gingival crevice with fibrous connective tissue beneath approaching a normal appearance. Just above the alveolar crest several small sequestra of bone being broken down by osteoclastic action are noted. Technical work was done by the Registry of Dental and Oral Pathology, Army Medical Museum, Washington, D. C.

95. GROWTH POTENTIAL AND APPOSITIONAL LIFE SPAN OF THE ENAMEL AND DENTIN FORMING CELLS IN THE HUMAN DECIDUOUS TEETH AND FIRST PERMANENT MOLARS. *M. Massler, B.S., D.D.S. and I. Schour, D.D.S., Ph.D., Dental School, University of Illinois, Chicago, Ill.* The final length (L) of the enamel rod or dentinal fibril represents the total amount of growth work which an ameloblast or odontoblast is capable of performing, and is therefore a measure of the growth potential of a given cell. It is the product of the rate of apposition (R) and the appositional life span (T) of that cell. $L = R \times T$. The rates of enamel and dentin apposition were obtained by the analysis of the teeth of 3 hydrocephalic infants vitally injected with sodium fluoride. The lengths of the enamel rods and primary dentinal fibrils were measured at various levels of the teeth and divided by the characteristic rate of apposition at that level to obtain the appositional life span of the respective formative cells. The functional life span of the ameloblasts was found to be maximal over each growth center and to grade to zero at the cemento-enamel junc-

tion. The functional life span of the odontoblasts during the formation of primary dentin showed a remarkable constancy within a given tooth. Differences in the length of the primary dentinal fibrils are thus the result of differences in the rate of apposition. The life span of the odontoblasts of different teeth shows a distinct antero-posterior gradient:

	I	II	III	IV	V	6
Maxillary Teeth	330 Days	315 Days	450 Days	450 Days	600 Days	750 Days
Mandibular Teeth	300 "	300 "	400 "	500 "	600 "	750 "

96. DOMESTIC WATER AND DENTAL CARIES III. FLUORINE IN HUMAN SALIVA. *F. J. McClure, National Institute of Health, Washington, D. C.* The saliva samples analyzed consisted of twenty 100 cc. specimens obtained from 10 adults living in Washington, D. C. or vicinity, eleven 100 cc. specimens from 11 children living in Amarillo, Texas, and 16 pooled salivas, representing from 40–200 individuals in each specimen, obtained from school children living in 8 cities in Illinois, 1 city in Ohio, 2 in Arkansas, and 1 in Virginia. Results of saliva analysis indicate that normal saliva contains approximately 0.10 ppm. or less of fluorine. There is some evidence in the data as obtained that domestic use of a communal water containing 3.8–4.0 ppm. of fluorine may increase slightly the fluorine excretion in the saliva. Although drinking waters containing 1.2–1.8 ppm. of fluorine are found associated with unusually low dental caries experience rates, the consumption of these waters caused no corresponding rise in the fluorine content of the saliva as shown by the results thus far obtained.

97. INCIDENCE OF SUPERNUMERARY AND CONGENITALLY ABSENT UPPER SECOND INCISOR TEETH IN 81 CASES OF HARELIP OR CLEFT PALATE. *Jerry A. Millhon, D.D.S., and Edward C. Stafne, D.D.S., Mayo Foundation, Rochester, Minn.* Eighty-one cases of cleft palate and harelip in which there was no record of previous extraction of teeth were studied. Of the 81 patients, 60 had cleft palate and 21 harelip. Of the 21 patients who had harelip, 1 also had a supernumerary maxillary second incisor. Of the 60 patients who had cleft palate 22 also had supernumerary maxillary second incisors, an incidence of more than 1 in each 3 cases. This incidence of supernumerary maxillary second incisors in our cases of cleft palate is higher than that among normal persons, for in routine examination of

48,500 patients only 1 supernumerary maxillary second incisor was found per 2,500 persons. When supernumerary maxillary deciduous second incisors were present, there was also a tendency for formation of permanent supernumerary second incisors. In 1 case with bilateral cleft, 2 supernumerary second incisors were present, 1 on each side. Second incisors were congenitally absent in some of the 81 cases; the incidence was more than 1 for each 11 cases. The cleft in every instance was situated between a second incisor and supernumerary second incisor. The dental groove which is present before the several bony parts coalesce to form the maxilla is principally instrumental in directing location of the forming dental tooth bud. Any cleft malformation may be the cause of formation of supernumerary teeth by splitting the developing tooth bud during its early period of formation. It is also conceivable that the second incisor may be obliterated, congenitally absent or markedly malformed.

98. EXPERIMENTAL INJECTIONS OF FIBROSING SOLUTIONS INTO THE TEMPOROMANDIBULAR JOINTS OF MONKEYS. *Sanford M. Moose, D.D.S., College of Physicians and Surgeons, San Francisco, Cal.* (Histologic examination made by the Department of Pathology of the Stanford University) The project embraced a series of injections of 5 per cent sodium psylliate into the temporomandibular joints of Rhesus monkeys to determine the effect of prolonged treatment by injection of excessive amounts into a joint similar to the temporomandibular joint of human beings. Treatment was administered weekly for a period of a year and the quantity was 0.5 cc. Necropsies revealed that changes were confined to the periarticular tissues and that the joint proper was unaffected. The duration of the artificial fibrosis produced has not been determined. The treated joints of part of a second group of animals will be examined 6 months after discontinuing treatment. The joints of the remainder of this group of animals will be examined 1 year following the last treatment.

99. THE SPEED OF CENTRIFUGAL CASTING MACHINES. *Raymond E. Myers, D.D.S., B.S., and John P. Curd, Jr., B.S., D.D.S., School of Dentistry, University of Louisville, Louisville, Ky.* The speed of centrifugal casting machines was determined by measuring the time required for the cross-bar to complete consecutive revolutions, beginning with the first and ending some time after the machine had reached

its maximum speed. The start of each revolution was recorded by means of a writing point on a revolving smoked drum. The intervals were measured by tracing the vibrations of an electrical tuning fork across the movements of the writing point. Calculations were made for the speed of the machine at any instant. The speed of the following types of centrifugal casting machines was measured: 1. uncoiling spring; 2. electrical; 3. hand crank; and 4. unwinding string. (To be published in *J. D. Res.*)

100. EFFECT OF MEDICAMENTS ON THE MOTILITY OF THE ORAL FLORA. II. SUPPLEMENTARY REPORT. *S. Leonard Rosenthal, D.D.S., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* This report on 20 additional medicaments supplements the original report on 68 substances. The motility test more nearly approximates actual clinical conditions than does the Rideal-Walker test because it uses the actual bacteria which the drug is to destroy in the patient's saliva, in addition to the usual growth tests for non-motile microorganisms. Having little or no effect on motility or on the non-motile oral flora are: sulfanilamide, sulfapyradine, sulfathiazole, cevitamic acid, viosterol, a suspension of brewer's yeast, Kaodrox, Aludrox, Amphyl, Aerosol, Teel, Bico, Xttrium, pectin and its metallic salts. The efficient substances which instantly stopped all motility and inhibited growth of the non-motile organisms are: Sobisminol, Zephiran, Tergitol and sodium carbonate.

101. THE DECIDUOUS AND PERMANENT TEETH IN CONGENITAL SYPHILIS. *B. G. Sarnat, M.D., D.D.S., I. Schour, D.D.S., Ph.D., N. G. Shaw, M. D. and R. Heupel, D.D.S., School of Dentistry, University of Illinois; Rush Medical College, University of Chicago, and Children's Memorial Hospital, Chicago, Ill.* The effect of systemic disease on growing teeth depends upon the stage of tooth development which is active at the particular time. In congenital syphilis the teeth may show disturbances in the developmental phases which occur during the neonatal and earliest infancy periods. At this time the deciduous teeth are active in enamel formation (apposition) and may therefore show hypoplasia (chronologic enamel aplasia); while the permanent teeth which are active in morpho-differentiation may show a disturbed dentino-enamel junction with a resulting characteristic distortion of the crown (Hutchinson incisor, Moon molar). Subse-

quent enamel formation is usually not affected. Distortion of the morphologic pattern of the permanent teeth in congenital syphilis is a symptom of systemic disease which occurred early in life but is not manifested clinically for several years until the teeth have erupted. By means of intraoral radiographs the dental diagnosis may be made prior to eruption.

102. PHARMACOLOGICAL EFFECTS OF MONOCAINE HYDROCHLORIDE IN EXPERIMENTAL ANIMALS. *June R. Schamp, Ph.D., Harvey M. Schamp, Ph.D. and M. L. Tainter, M.D., College of Physicians and Surgeons, San Francisco, Calif.* Observations have been made on toxicity and other pharmacologic properties of monocaine to determine its desirability as a clinical local anesthetic solution. Its solubility is limited, only about a 2.6 per cent solution can be made in water and 1.3 per cent in normal salt solution at room temperature. The pH of a 2 per cent solution is 5.20 and of a 1 per cent solution, the concentration used clinically, 5.59. It decomposes in solution to a significant degree after exposure to light or air for from 7 to 40 days, is broken down by heating in an autoclave of sufficient duration and temperature to insure bacteriological sterility. Monocaine anesthetizes frogs' skin when tested topically by the Turk method about as well as cocaine and definitely better than procaine. When applied directly to the sciatic nerve in frog muscle-nerve preparations, its anesthetic potency is practically same as that of procaine. However, a greater toxicity of monocaine over procaine is demonstrated for both these types of preparation, larger percentages of them failing to recover when the drug is removed. The fatal dose of monocaine for white rats intravenously is 28 mgm./kilo as compared to 39.5 mgm. for procaine; in white mice intraperitoneally the fatal dose of monocaine is 211 mgm./kilo as compared to 125 for procaine. The significance of this discrepancy in mortality for the 2 species and by the 2 routes of administration is being further investigated, together with other pertinent manifestations of the actions of these materials.

103. FLUORINE CONTENT OF MILK AS AFFECTED BY THE AMOUNT OF FLUORINE IN THE DRINKING WATER OF THE COW. *Margaret Cammack Smith, M. Vavich, and H. V. Smith, Agriculture Experimental Station, Arizona University, Tucson, Ariz.* Does milk from cows raised in communities in which mottled enamel is endemic because of

the presence of fluorine in the local water supply contain fluorine in toxic amounts? In order to obtain an answer to this frequent question, sodium fluoride has been added to the drinking water of 2 cows at 7 concentration levels within the range of 0.2 to 500 ppm. of fluorine. The additions of the fluoride at the highest levels gave a slightly salty taste to the water and reduced somewhat the consumption of water and the milk supply. Analyses of the milk of the cows drinking these waters showed only small differences in fluorine content within the range of 0.2 to 0.4 ppm. The fluorine of the urine of the same cows sampled at the same time each day, showed however an increase from 0.2 to 113 ppm. It appears, therefore, that wide differences in the fluorine content of the drinking water of cows produces only slight increases in the fluorine content of the milk which is secreted.

104. PULP STONES AND HYPERCEMENTOSIS IN ARTHRITIS. *Sidney Sorrin, D.D.S., New York University College of Dentistry, New York, N. Y.* The purpose of this study was to determine whether any relationship exists between either pulp stones or hypercementosis and arthritis. Out of 200 cases of arthritis studied at Montefiore Hospital, 100 were edentulous and therefore of no value in this investigation. (In this edentulous group, the results of prior extractions of all the teeth were disappointing; the arthritis still persisted). Only those cases which had at least 15 teeth distributed between the 2 jaws were included in the study. Forty-six of the remaining 100 arthritics met these requirements. The greatest number of cases (37) was found among the chronic infectious group; 6 were found in the degenerative and 3 in the specific groups. A control group of 48 cases of so-called healthy individuals (non-arthritic) was selected at random in the Periodontia Clinic at the College of Dentistry. Only those cases which presented at least 15 teeth distributed between the 2 jaws were considered. The results of the statistical study are observed by 3 tables of control and arthritic groups. From the number of cases presented, there seems to be no relationship between pulp stones or hypercementosis and arthritis. (To be published in *J. D. Res.*)

105. ACTIONS OF SODIUM BISULFITE IN LOCAL ANESTHETIC SOLUTIONS. *M. L. Tainter, M.D., A. H. Throndson, D.D.S. and H. M. Leicester, Ph.D., College of Physicians and Surgeons, San Francisco, Calif.* Sodium bisulfite in solution decomposes over a period of days,

liberating half a molecular equivalent of acid. This shifts the pH of solutions containing it by several pH units, even in the presence of buffer materials such as procaine and epinephrine. As a result, local anesthetic solutions containing sodium bisulfite become more acid on standing and may reach a final value around 3.0. In 318 patients, 506 injections of procaine-epinephrine were made for oral surgical procedures. Observations on the progress of the anesthesia and physiological responses thereto were made according to our standard "blind test" technique. It was found that the volumes of anesthetic required, the speed of onset and duration of anesthesia were not altered by the presence of 0.1 per cent sodium bisulfite in the anesthetic solution. However, incomplete anesthesia was increased in frequency from 12.7 to 20 per cent by its presence, and swelling at the site of injection and trismus of the muscles from the resulting irritation was almost doubled. Otherwise the anesthesia appeared unmodified by this material. The results indicate that sodium bisulfite makes local anesthetic solutions more irritating to the tissues and that therefore steps should be taken to replace this with some more desirable preservative.

106. COMPARISON OF MONOCAINE AND PROCAINE AS LOCAL ANESTHETICS. *A. H. Throndson, D.D.S., and M. L. Tainter, M.D., College of Physicians and Surgeons, San Francisco, Calif.* Two hundred and fifty-one patients have been used to study the relative merits of monocaine hydrochloride 1 per cent plus 1:75,000 epinephrine, and procaine hydrochloride 2 per cent plus epinephrine 1:50,000 in oral surgery according to our previously described blind test technique. Monocaine produced about 1 hour longer anesthesia than procaine. This advantage was offset by the fact that it caused more pain when injected, and somewhat more reactions, in spite of the lower epinephrine content. Greater local tissue injury was shown after monocaine by the increased incidence of painful injection sites in the days following the operation. Aside from these differences, the responses of the patients to the 2 anesthetics were very similar. Monocaine therefore appears to be a useful local anesthetic, whose effects are not greatly different from those of procaine, in the concentrations commonly used.

107. BROWN SPOTS ON THE TEETH. *S. S. Turesky, A.B., Tufts College Dental School, Boston, Mass.* "Brown spots" on the teeth represent one of the surface changes other than caries which has been

given little consideration. For the purpose of adding to our knowledge of this change, a clinical study of the occurrence of "brown spots" was carried out on 967 accessible proximal surfaces of permanent teeth. The findings suggest a positive relationship between "brown spots" and increasing age, and indicate that they are more common on molars and premolars than on incisors, and that they are more prevalent on surfaces of teeth approximating tooth spaces (extracted teeth) than on surfaces proximal to caries.

108. FOLLOW-UP STUDIES IN BACTERIOLOGY OF PULP INVOLVEMENTS OF SILICATE FILLED TEETH. *Morton F. Yates, D.M.D., and Fred W. Morse, Jr., M.D., Harvard University Medical and Dental Schools, Boston, Mass.* In a group of 265 cases of pulp-involved teeth carefully followed for from 1 to 7 years by examination and roentgenograph, we find 42 which developed following placement of silicate fillings. Did these teeth respond differently to treatment, or show different bacteriological results than teeth with pulp involvements not associated with silicate fillings? The original roentgenographic conditions showed 3 cases with normal radiolucency (7 per cent), 27 cases with diffuse radiolucency (64 per cent), 12 cases with circumscribed radiolucency (29 per cent). The bacteriological findings showed the presence of gamma streptococcus, 34 per cent; alpha streptococcus, 6.4 per cent; *Staphylococcus albus*, 34 per cent; and *Staphylococcus aureus*, 10.6 per cent. *Bacillus acidophilus*, subtilis and yeast appeared in approximately the same proportion, from 2 to 6 per cent, as in the total group of cases. Although we find an increase in the amount of staphylococcal infection in the pulp involvements following silicate fillings, there is barely a significant difference from the findings in the entire 265 cases. Follow-up records showed that all the cases under silicate fillings showed definite improvement following treatment. However, an average of 5.8 treatments was required to obtain sterile canals in these cases, as compared with an average of only 4 treatments for the group of cases showing circumscribed radiolucency. There is no significant difference in the original roentgenographic findings between the cases following silicate fillings and the 265 cases as a whole.

109. EPITHELIAL TUMORS OF THE JAWS IN MICE. *Edward V. Zegarelli, A.B., D.D.S., School of Dental and Oral Surgery, Columbia University, New York City.* Jaw tumors of 72 mice obtained from the

Maud Slye colonies of the University of Chicago form the basis of this report. After gross and radiographic examination, the heads were decalcified and sectioned serially. Most of the animals exhibited unilateral or bilateral mandibular growths, while in the remaining few, maxillary tumors were found. From radiographic evidence and histological study, the growths were determined to be unilocular cysts; multilocular cysts some with epidermoid carcinoma characteristics; sarcomas; odontomas and mixed tumors. Interest was chiefly in adamantinomas and most of the animals showed this type of growth. Contrary to opinions expressed in the literature that these epithelial tumors arise from 1. adamantine cells, 2. embryonal nests, 3. epithelial cells of Malassez, our findings showed them to arise from the outer undifferentiated epithelial cells of the enamel organ. Because these growths are proliferations of nonspecialized epithelial cells, they are more properly classified as epitheliomas rather than adamantinomas. They are further subdivided into 1. unilocular cystic, 2. multilocular cystic with or without squamous or basal cell characteristics, 3. multilocular cystic with epidermoid carcinoma characteristics. Enamel was never found in these epithelial tumors. Whenever enamel was seen, dentin was also present which placed the growth in the odontoma classification.

110. DILANTIN HYPERPLASTIC GINGIVITIS: ITS TREATMENT AND PREVENTION. *Daniel E. Ziskin, D.D.S., Lewis R. Stowe, D.D.S., Edward V. Zegarelli, A.B., D.D.S., School of Dental and Oral Surgery, Columbia University, New York, N. Y.* The gingival reaction of a number of patients of varying ages under treatment for epilepsy with Dilantin was studied. The history of 7 children and 7 adults are reported in a detailed table. The clinical information indicates that the degree of hyperplasia of the gingival tissue is not in proportion to the amount of the drug ingested. The dissimilarity between dilantin hyperplasia and scurvy is discussed both from the clinical and histological viewpoint. Histologically, the hyperplasia appears largely due to the increased collagen formation in the corium with a slight increase in the epithelium. No evidence of epithelial pearl formation was observed. Horizontal formations of epithelial pegs microscopically may simulate pearl formation. The influence of oral hygiene as a preventive and curative measure in a number of cases is

discussed and is considered of definite value. Different segments of the mouth in the same individuals were taken as controls. Surgical removal of gross tissue is recommended in those cases where hyperplasia is extreme. However, growth and regrowth of tissue can best be prevented by vigorous brushing and massage and should be started concurrently with dilantin treatment. The drug need not be discontinued because of the gingival hyperplasia.

XII. Necrology*

G. B. W. Winter, p. 291; A. Földi, p. 292

Dr. George Ben Wade Winter: 1878–1940

Dr. George Ben Wade Winter, a pioneer in the field of oral surgery, passed away on March 28, 1940 at his home in St. Louis, Missouri. He was born in Brooklyn, New York April 14, 1878. He attended St. Louis University from which he was graduated in 1900, and soon became a professor of that University. During the World War, he taught in the Officers' School of Neurological, Plastic and Oral Surgery. He also taught the extension courses at Columbia University.

The removal of teeth particularly the impacted mandibular third molar engaged his attention from the beginning and he devoted many years of research and study in that field of dentistry; he coined the word "exodontia" in 1913 and published a textbook on the subject. He was made Professor of Exodontia in the Dental School of Washington University and held this position for a number of years. He was an able teacher and influenced all those who came in contact with him. Further studies made on the impacted mandibular third molar resulted in a monumental text, written exclusively on this subject and published in 1926, and this was followed by many other articles. His fame became widespread. One of his many achievements was a sound movie on the "Fundamental Principles for the Technical Removal of the Mandibular Third Molar" which was presented at the Second District Dental Society of Brooklyn in 1936.

Dr. Winter was a past president of the St. Louis Dental Society (1921), the Missouri State Dental Association (1927) and the American Dental Association (1936), and he also was a trustee of the latter

* Sixth annual report of Necrology Committee.

organization. He was elected to active membership in the International Association for Dental Research on March 28, 1928. He was a charter member of the American Society of Oral Surgeons and Exodontists, a Fellow of the American College of Dentists and an honorary member of the State Societies of Ohio and Oregon, the Oral Surgery Section of the Second District Dental Society of New York, the American Dental Society of Europe and the Dental Societies of Cuba, Chile, Uraguay, Peru and Argentina. He was also a member of the honorary society of Omicron Kappa Upsilon.

Many honors came to Dr. Winter in appreciation of his outstanding contributions to dental science. He was awarded the Newell Sills Jenkins Medal in 1933 and in 1936 he received a gold medal and scroll from the Rhode Island State Dental Society in recognition of his research work. In 1938 he received a gold medal from the Odontological Society of Havana, Cuba.

The dental profession has been greatly saddened by the death of Dr. Winter. It has lost a great scientist and a valued worker. The public, too, has suffered a severe loss, for he was both a friend and a benefactor to the many people who daily came in contact with him.

DR. ALEXIS FÖLDI: 1895–1940

Dr. Alexis Földi, an earnest worker in the research field, was born in Kassa, Hungary on April 4, 1895. He received the degree of Doctor of Medicine from the University of Budapest and immediately specialized in dentistry. He was assigned the post of assistant at the Policlinic of the University Dental Department. His post of Attending Dental Surgeon at the Hospital for Tuberculosis in Budapest awakened his interest in the effects of tuberculosis on the oral tissues. His publications on this and allied subjects appeared in German and in the Hungarian language. He was elected to active membership of the Budapest Section of the International Association of Dental Research on March 18, 1934.

Dr. Földi left his native land for political reasons and settled in Portland, Oregon, where he was preparing for the degree of Doctor of Dental Surgery when he died on August 31, 1940 of an acute leucemia in his forty-fifth year.

The friends of Dr. Földi and members of our Association regret the passing of a promising investigator.

XIII. Executive Proceedings

A. Reports of Secretary and Council

Secretary: Resignations have been received from Alês Hrdlicka, A. Leroy Johnson and Frederick McKay. Their names together with those as reported by the necrology committee have been taken from the list of membership, now totaling 535.

Council: The Council selected St. Louis and the Hotel Jefferson as the site for the 19th General Session, approved the selection of honorary vice-presidents, cancelled the dues of foreign members for the current year and nominated candidates for the general officers for the official ballot. The offer of Samuel M. Gordon and the contributors to Dental Science and Dental Art to establish Grants-in-aid was referred to a committee, Raymond E. Myers, Isaac Schour and H. B. G. Robinson (Chairman), for consideration. Their report in favor of accepting the grant was adopted and the committee, enlarged by the addition of H. Trendley Dean and Philip Jay, was authorized to prepare a plan for the operation of the fund and make grants in accordance therewith. The special committee appointed to study proposed plans for the publication of the *Journal of Dental Research* (H. B. G. Robinson, Chairman) reported that the offer submitted had been withdrawn. This report was accepted and the committee discharged.

At sessions held at the Hotel Jefferson just previous to and during the meeting, the Council received the ballots collected by the secretary on the question of adopting the revisions to the constitution and the proposed by-laws, referred these to a teller's committee for counting (E. Kotanyi, Chairman), authorized the appointment of a committee (Wm. J. Gies, Chairman) to nominate candidates for the new offices created by the constitutional revisions; approved the names of the 27 nominees listed on pages 300–301 as eligible for membership; recommended that Frederick McKay, recently resigned, because of his long interest in dental research and in this Association be made a life member; and urged the election of Wm. J. Gies as a life member of the Council. They also heard reports from all officers except the treasurer and favored their approval.

B. Executive Sessions

Minutes of the Eighteenth General Session were approved as printed in the Proceedings. The foregoing acts and recommendations

of the Secretary and Council were accepted and approved, including all recommendations as reported above and specifically; the election of all nominees for membership approved by the Council and listed on pages 300–301, the audited reports of the secretary, business manager of the *Journal of Dental Research* and the treasurer of the endowment fund. The report of the Necrology Committee was read (See pages 291–292 of these proceedings).

For the Teller's Committee, Dr. Kotanyi reported that of 365 valid ballots counted, 364 favored approval of the revisions of the constitution and 363 voted for adoption for the by-laws. Since 359 votes represent a two-thirds majority of the membership of 535, the revisions were declared adopted and in effect as of the date of this meeting. Tellers appointed to canvass the official ballots, Chase and Kaiser, reported results of the official ballot. Ballots were received from the following members:

Aisenberg, Anderson (B. G.), Appleton, Archer, Baker (Zelma), Bauer, Beall, Bear, Beube, Bibby, Bier, Blackberg, Bodecker, Boulger, Boyle, Brand, Brandhorst, Brashear, Brekhus, Brodsky, Bryan, Brown, Bunting, Burkett, Cahn, Carr, Cheyne, Clough, Cook, Coolidge, Coy, Crawford, Cushman, Darlington, Davis, Dean, Dobbs, Dunning, Edwards, Ehrich, Elliott, Epstein (I. A.), Epstein (S), Erickson, Figg, Finn, Fleming, Fraser, Freeman, Frey, Friesell (F. C.), Friesell (H. E.), Gardner, Gies, Goldman, Grossman, Grove, Hadley, Hall, Hammond, Harrison, Hartley, Hatch, Hatton, Hellman, Hidnert, Higley, Hill, Hine, Hirschfeld, Hodge, Hoffman, Hollander, Hutchinson, James, Jump, Kanthak, Kazanjian, Kelsey, Kotanyi, Krogman, Lalonde, Lasby, Leavitt, Lefkowitz, Leonard, Logan, Losch, Lowery, Luckhardt, Kaiser, Kaplan, Kitchin, Klaffenbach, Klatsky, Klein, Krasnow, Krogh, Main, Mann, McCall, McCollum, McCrea, Merkeley, Merritt, Midgley, Miller (H. A.), Miner, Mueller (A. H.), Mueller (E), Myers, Neustadt, Neuwirth, Newman, Noyes (H. J.), Oblatt, Orban, Paffenbarger, Palmer, Pond, Potts, Prinz, Ray, Restarski, Robinson (J. Ben), Rosenthal, Rule, Ryder, Salzman, Scherer, Scheu, Schroff, Sebrell, Sedwick, Shapiro, Simon, Skillen, Skinner, Smith (M. C.), Sognnaes, Sommer, Sorrin, Souder, Spangenberg, Spector, Speidel, Stafne, Stephan, Swanson, Taber, Tainter, Tanchester, Taylor (N. O.), Taylor (W), Teuscher, Thoma, Thomson, VanKirk, Volker, Volland, Waldron, Ward, Waugh, Weatherford, Weinmann, Welker, Wessinger, Wheeler, Willman, Wolfe (F. J.), Worman, Wright (G. H.), Yates, Zander, Ziskin. Total—175.

Due to the emergency caused by the adoption of the revisions to the constitution and in accordance with the recommendations of the special committee authorized by the Council, the newly created offices of secretary-treasurer, editor and two additional trustees were filled by election at the Sunday afternoon session. List of the officers elected appears on page 300 of these proceedings.

At the concluding executive session the Council was authorized to

approve the dues assessment for the year 1941–1942; to waive dues of foreign members; to approve the selection of honorary vice-presidents; to select the time and place of the next general session; to supervise the transfer of the treasurer's funds from New York to Chicago including approval of plans for the operation of the office of secretary-treasurer. By unanimous vote the secretary-treasurer was instructed to write letters of appreciation to the Deans of those dental schools that have supplied conveniences for the dispatch of Association business, and to convey to the staff of the Hotel Jefferson and to the local arrangements committee the generous appreciation of the Association for all those facilities contributing to the success of this meeting.

Adjourned.

EDWARD H. HATTON, *Sec.-Treas.*

C . JOURNAL OF DENTAL RESEARCH

a. Committee on Endowment

WILLIAM J. GIES ENDOWMENT FUND

Financial statement as of March 10, 1941

Compiled by L. M. WAUGH, *Treasurer*

Balance, as per report of March 10, 1940*..... $20,969.08

	Pledge	*Amt. previously paid*	*Paid in 1940–41*	*Unpaid Balance*	
American College of Dentists.....	5000	2000	1000	2000	1000.00
N. Y. Academy of Dentistry.....	5000	4500	500		500.00
L. M. Waugh.....	1000	600	200	200	200.00
J. B. Mann Study Club, Wash., D. C..	1000		100	900	100.00
Michigan State Dental Society.....	500	250		250	
Illinois State Dental Society.....	1500	700	200	600	200.00
Geo. C. Paffenbarger.....	250	100	25	125	25.00
Harry Kaplan.....	250	50		200	
Queens Dist. Dent. Socty., N. Y.....	100	50	25	25	25.00
Harold W. Krogh.....	100	50	50		50.00
Herman F. Bernstein.....	100		50	50	50.00
First Dist. Dent. Socty., Kansas.....	100		20	80	20.00
Ohio State Dent. Soc. yrly int. on.....	2000		60		60.00
Bethany Meth. Hospital, coupons.....		2.25	4.50	29.25	4.50
Alpha Omega Fraternity, $25 yrly....		100	25		25.00
Gordon L. Teall.....	10		5.00	5.00	5.00

* This is an abridged copy of the report and lists only receipts for the past year and the balances on hand at the beginning and close of the year. Report of March 10, *1940* appeared in the J. D. Res. **19**: 332, 1940.

Passaic County Dental Society	29.00
G. Fred Hale	10.00
D. L. Pridgen	10.00
H. O. Lineberger	10.00
Wilbert Jackson	10.00
R. M. Olive	10.00
John A. McClung	5.00
D. T. Smithwick	1.00
B. J. Boyle	1.00
O. W. Brandhorst	9.00
Anonymous	8.75
E. A. Branch	1.00
Plainfield Dental Society	14.00
Tri-County Dental Society	25.00
Essex County Dental Society	44.50
A. H. Merritt	100.00
Northeast District Dental Society	15.00
Monmouth County Dental Society	25.00
O. J. Fusilier	1.00
Barrett Malbin ($5.00 of this sent to Journal)	7.00
H. J. Lee	1.50
North Dakota State Dental Asso.	130.00
C. S. Foster	10.00
F. O. Alford	10.00
L. R. Kramer	100.00
Members of Michigan State Dental Society	14.00
Bergen County Dental Society, N. J.	50.00
O. E. Hoffman	5.00
S. E. Pond	5.00
L. W. Baker	5.00
Georgia Dental Association	94.35
I. A. D. R.—Boston Section	25.00
Indiana State Dental Society	200.00
N. J. State Dental Society	100.00
L. A. Founer	5.00
Victor H. Hilgemann	6.00
R. C. Shurr	5.00
J. B. Carr	3.00
Raymond E. Gill	1.00
Nebraska State Dental Association	50.00
Louis J. Wyatt	100.00
Indiana Dental Association	34.00
University of Southern California	13.25
Lambda Chapter, Omicron Kappa Upsilon	100.00
North Carolina Dental Society	100.00
C. H. Schott	25.00

Colorado State Dental Association	300.00
W. T. Chambers	5.00
Sacramento District Dental Society	10.00
Northwest Kansas District Dental Society	25.00
J. Scott Walker	10.00
O. W. Brandhorst	25.00
Thos. J. Hill	10.00
Golden Belt Dental Society, Kansas	25.00
O. M. Davis	2.00
7th District Dental Society, Kansas	88.00
Southern District Dental Society, Kansas	25.00
H. C. Gilliland	1.00
John Morgan	5.00
C. A. Scrivener	1.00
F. C. Carothers	1.00
J. Victor Benton	1.00
R. R. Miller	1.00
Lowell Crawford	1.00
J. A. O'Grady	1.00
W. E. Cutler	1.00
H. D. Mosier	1.00
M. A. Parrott	1.00
Jas. B. Sherry	1.00
T. C. Hansen	2.00
D. L. Smith	1.00
Jas. Nuckolls	2.50
Texas State Dental Society	107.00
Wisconsin State Dental Society	273.00
W. R. Roland	1.00
No. Sec. Amer. College of Dentists, Calif.	100.00
R. E. Olson	10.00
A. F. Jackson	25.00
I. A. D. R., N. Y. Section	25.00
P. W. Woods	5.00
J. H. Yearick	25.00
G. J. Roth	25.00
A. W. Lindsay (to make good exchange charge)	.20
H. L. Bunker	10.00

Following are included in check, dated Phildelphia Feb. 11th, 1941 from Dr. Louis I. Grossman, collected at the Greater Philadelphia Meeting. $1.00 was contributed by each: *A. R. Adams, Fred Adams, C. B. Addie, Karl Albert, Bruce Anderson, two Anonymous, 4–25¢ by friends, I. Barbell, Thos. Barratt, Stephen D. Baughan, D. W. Bell, Dr. Bell, I. B. Bender, Benj. Benedict, Jos. E. Bernstein, Harvey S. Bertel, H. C. Best, W. A. C. Bester, S. S. Bloom, G. Bizzozero, U. Blum,

* Names taken from signatures, sometimes not legible.

B. M. Brickman, E. Briggs, Dr. Britton, I. N. Broomell, B. Broudo, L. L. Brown, D. H. Brown, C. C. Bruno, Lester Burket, John Cane, Theodore Casto, Robt. Chain, J. F. Chermol, Frank Chumar, A. J. Clark, N. Clarvitz, Herbert Cohen, Geo. A. Coleman, E. R. Cornish, J. P. Courtman, Jas. W. Craig, S. E. Culler, J. P. Davidson, Geo. Davis, Wm. Daniel Day, G. F. DeLong, Climax Dental Supply Co., R. A. Denny, F. C. Denton, Edw. Derad, Thos. Dilworth, Dr. Doland, A. Dubroff, B. L. Eastwood, J. A. Eberly, J. Echternach, R. H. Ellis, B. E. Erikson, E. F. Everett, W. D. Everhard, M. M. Fintz, J. Fogg, J. Wallace Forbes, Frank Fox, A. Frank, J. Freedman, A. B. Gabel, Dick Gaber, Chas. S. Gaige, L. Galfand, A. L. Geisenhover, H. J. Ginns, J. H. Githens, M. M. Glasser, Ray J. Glezen, E. W. Greimer, I. Golden, H. Goomilow, L. Grace, P. P. Gross, F. M. Grosscup, N. R. Haig, R. L. Hart, R. U. Hennessy, Hendrickson of S. S. White, H. J. Henneka, W. Henry, G. Hinkson, J. E. Hirtle, F. H. Hoeffer, C. S. Holmes, C. Ivory, J. M. Jackson, S. Jaffe, J. K. Jennings, E. L. Kanaga, Frank Kanter, S. Katz, H. C. Keane of S. S. White, C. B. Keill, W. D. Kelly, R. M. Kerr, Jr., L. L. Keim, J. Kitchenman, H. U. Kless, M. Krauser, P. Kutz, W. F. Lang, Vernon Lapp, Saml. Lavine, A. S. Lawson, Sanford Lawyer, B. Lebby, M. Leof, Frank Leonard, W. T. Levergood, S. Levin, V. H. Levitz, B. A. Lincoln, J. H. Lock, A. J. Long, H. J. Lord, B. A. Lowry, S. Blair Luckie, Jas. W. Lyman, E. J. Lyons, W. Magann, E. A. Manning, M. B. Markus, C. S. Martin, J. C. Mason, C. B. Masseth, B. Masuda, H. Mathews, C. J. Mattis of S. S. White, R. C. Mears, B. M. Meiman, W. E. Mendel, Leon Metz, Earl Miller, F. D. Miller, R. E. V. Miller, M. E. Nicholson, R. H. Nones, Jr., E. J. Ohn, D. B. Olmos, A. L. Orr, Irving Parmet, Chas. Patton, O. C. Peters, Sara Pogost, Dr. Popkin, W. W. Powell, Edw. Pressman, A. Puls, Michael Quinn, Michael F. Quinn, Jr., Geo. Rankin, R. B. Rearick, Paul Reid, E. T. Ritsert, L. C. Rees, W. A. Reese, P. H. Richardson, S. W. Ridgeway, W. J. Robinson, J. T. Rothner, Milton Rose, S. L. Rosenthal, F. S. Rusca, John Sabritt, M. A. Salerno, B. Saturen, W. V. Scanlon, E. H. Schaeffer, Leon Schuck, J. Schwartz, Harry Schwartz, I. L. Schwartz, I. D. Scott, L. Serota, Simon Shapiro, H. D. Shields, W. R. Showacre, Benj. O. Silver, H. T. Silverman, J. Sindoni, S. B. Smith, S. F. Smolczynski, S. L. Snyder, E. L. Spellman, G. J. Stein, D. S. Stern, E. R. Strayer, R. H. Stuckland, Edw. Subin, G. W. Thompson, F. H. Travers, J. V. Tryon, D. C. Turkington, E. A. Ulrich, Wm. Updegrave, E. H. Velutini, A. L. Ventura, R. C. Walter, S. B. Wasserman, B. R. West, C. A. Whitcomb, H. E. Williams, R. W. Williams, J. E. Wittek, H. B. Wright, E. V. Wright, J. H. Yearick, H. Zelson, W. I. Zyner and Contributor. $2.00: Jas. A. Crosier, H. M. Vernon. $5.00: Vernonite Dental Co., five $1.00 Contributors, 12 $1.00 Commercial Exhibitors 245.00

J. Wesley Lucas 10.00

26,169.63

Disbursements 19,013.53

Balance in Empire Trust Co. bank as of March 10, 1941 ..... $7,156.10

1/1/41 Total Deposits $19,000 in savings banks as follows:

Date deposited	*Excelsior Savings Bank*	*Empire City Savings Bank*	*American Savings Bank*	*Total interest from 4/1/40 to 1/1/41*
3/11/40	$2000	$3500	$5000	
6/19/40	1000	1000	1000	
9/28/40	1000	500	1500	
12/20/40	1000	500	1000	
Total	5000	5500	8500	
Interest earned to 1/1/41	47.81	69.38	89.59	206.78

Amount solicited	50,000.00
Receipts & Pledges	30,633.88
Balance to be raised	19,366.12

Respectfully submitted

L. M. WAUGH,
Treasurer

b. Publication Committee

Complete separate reports were submitted by the Editor, Business Manager and Circulation Manager. These are briefly summarized.

Editor. There were 605 pages in Volume 19 devoted to 45 scientific papers and the Association Proceedings. This is an increase in both number of pages and number of scientific papers over the previous volume. The 45 published papers were submitted from 16 American universities, 1 foreign university, the National Institute of Health, a dental dispensary, a city vocational school and 2 from unaffiliated authors. Nineteen papers were annotated as supported by grants and 16 as having been read at scientific society meetings.

Business Manager. Total amount collected in 1940 was $5,547.69. Disbursements were $3,944.44. The cost of printing, binding and mailing Volume 19 was $3,908.97, miscellaneous expenses $362.90. The surplus will be used to increase Volume 20 (this volume) by approximately 100 pages.

Circulation Manager. The total paid circulation has remained fairly constant for the past three years. Twenty-five per cent cancellations have been made up by new subscribers. By reducing the number of copies distributed to non-paying individuals the press run has been reduced to about 1450.

D. LIST OF OFFICERS AND NEW MEMBERS ELECTED

a. Officers (1941–42)

ACTIVE: *President*—Isaac Schour, University of Illinois. *President-elect*—Charles F. Bodecker, Columbia University. *Vice-president*—Philip Jay, University of Michigan. *Secretary-treasurer*—Edward H. Hatton, Northwestern University. *Trustees*—Arthur H. Merritt (3 years), Edward H. Hatton (4 years) and Leuman M. Waugh, Columbia University (5 years). *Editor*—Hamilton B. G. Robinson, Washington University (2 years). (*Publication Committee*—Hamilton B. G. Robinson, J. Frank Hall, Medical College of Virginia and M. W. McCrea,* University of Maryland [2 years]).

b. New Members[1]

Bethesda, Md. Selwyn D. Collins, A.M., Ph.D., and W. M. Gafafer, Ph.B., A.M., Sc.D., both from National Institute of Health.

Boston, Mass. Mark D. Elliott, D.D.S., Herbert I. Margolis, D.M.D., and Carl T. Nelson, A.M., D.M.D., all of Harvard University.

Chicago, Ill. Robert E. Blackwell, M.S., D.D.S., Leland R. Johnson, D.D.S., M.S.D., and Arne F. Romnes, D.D.S., M.S.D. of Northwestern University, and Philip S. Faillo, D.D.S., Chicago College of Dental Surgery.

Cleveland, Ohio. Conrad C. Gilkison, D.D.S., Western Reserve University.

Detroit, Mich. Horton Kimball, D.D.S., Private Practice.

Fremont, Ohio. Willis B. Holmes, Ph.D., W. V.-B. Ames Co.

Helsinki, Finland. Pekka Nironen, D. Odontol., Private Practice.

Indianapolis, Ind. Hannah E. Silberstein, M.S., University of Indiana.

London, England: Paul Pincus, D.D.Sc., Ph.D., L.D.S., Private Practice.

Louisville, Ky. George B. Diefenbach, B.S., D.D.S., University of Louisville.

* Resigned, March, 1941.

[1] A list of members, as of Nov. 15, 1940, was published in the *J. D. Res.*, 19: 592, 1940. A list of the members elected in 1940 was published in the *J. D. Res.*, 19: 336, 1940.

Minneapolis, Minn. Charlotte Fisk, M.A., M.D., University of Minnesota.

New York, N. Y. Maurice Buchbinder, B.S., D.D.S., Private Practice; Moses Diamond, D.D.S., Bion R. East, D.D.S., and B. O. A. Thomas, M.S., D.D.S., all of Columbia University; Lewis Fox, D.D.S., Hospital for Joint Diseases.

Rochester, N. Y. Norman F. Simmons, B.S., D.M.D., University of Rochester.

Rochester, Minn. Adrian O. Hubbell, B.S., D.D.S., Mayo Foundation.

St. Paul, Minn. Sherwood R. Steadman, D.D.S., Private Practice.

St. Louis, Mo. Kermit Christensen, Ph.D., St. Louis University.

Washington, D. C. H. J. Caul, B.S., National Bureau of Standards.

E. MEMBERS PRESENT AT ONE OR MORE SESSIONS

SECTIONS. *Ann Arbor:* Bunting, Crowley, Jay, Peyton. *Baltimore:* Robinson. *Boston:* Bibby, Boyle, Etherington, Miner, Morse (F. W.). *Chengtu:* Agnew (M. C.), Agnew (R. C.). *Chicago:* Blayney, Bradel, Brodie, Coolidge, Denton, Fosdick, Freeman Harrison, Hatton, Hemmens, Hine, Jump, Kesel, Logan, Majerison, Noyes (F. B.), Orban, Pendleton, Schour, Schram, Skillen, Skinner, Stephan, Tylman, Wasserman, Weinmann, Wessinger, Willett, Willman, Zander. *Cleveland:* Chase, Hill, Taylor (P. B.), *Columbus:* Kaiser, Kitchen, Spangenberg. *Houston:* Elliott, Kotanyi. *Indianapolis:* Cheyne, Crawford, Silberstein. *Iowa City:* Bryan, Speidel. *Louisville:* Diefenbach, Myers, O'Rourke, Van Huysen. *Minnesota:* Armstrong, Brekhus, Lasby, Ray, Rudolph, Stafne. *New Orleans:* Tiblier. *New York:* Beube, Bevelander, Bodecker, Breitner, Diamond, Gies, Hemley, Holliday, Lefkowitz, Leonard, Newman, Stein, Thomas, Ziskin. *Palestine:* Gottlieb. *Philadelphia:* Burket, Crowell, Taylor (N. O.). *Pittsburg:* Cox. *Richmond:* Arnim, Bear, Coy, Clough, Hall. *Rochester:* Deakins, Hodge, Manly, Simmons, Sognnaes, Volker. *St. Louis:* Bauer, Bleiker, Boling, Brandhorst, Gurley, Hampp, Koch, Lischer, Main, Purcell, Robinson, Wheeler. *San Francisco:* Fleming, Hughes, Sloman. *Toronto:* Mason. *Washington:* Arnold, Dean, McClure, Paffenbarger, Souder. *Unattached:* Moore (T. E.), Rabkin. Total—119. (All U. S. Sections except Detroit represented in attendance.)